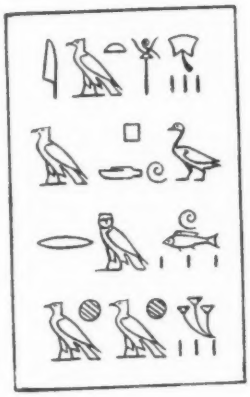
# THE JOURNAL OF WILDLIFE MANAGEMENT



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THE JOURNAL OF WILDLIFE MANAGEMENT

VOLUME 5 OCTOBER 1941 NUMBER 4

# BIG GAME IN MONTANA FROM EARLY HISTORICAL RECORDS

*Elers Koch*

The journals of all the early explorers of the West are filled with descriptions of the game conditions they encountered. Subsisting on the resources of the country as most of them did, if game was abundant, they feasted, and enjoyed the sight of the multitude and variety of wild animals. If game was scarce or absent, they starved, and their journals recorded the hardships of famine.

The earliest and most complete record of conditions in primeval Montana is of course the journal of the Lewis and Clark expedition of 1804 to 1806. After wintering with the Mandan Indians in what is now North Dakota, the expedition continued up the Missouri River by boat in the spring of 1804. The valleys of the upper Missouri and Yellowstone at that time supported an aggregation of game animals that for number and variety exceeded anything the eye of man has ever looked upon, except possibly on the plains of East Africa. The combination of the vast expanses of prairie grass, which furnished unlimited pasture, with the cottonwood bottoms of the rivers affording wooded shelter, and the occasional "bad lands" and breaks with their further variety of habitat, rendered this region a paradise for game animals. A few extracts from the journal which are representative of the daily experience, follow:

On April 21, below the Yellowstone. "We saw immense quantities of buffalo, elk, deer, antelope, geese, and some swan and ducks, out of which we procured three deer and four buffalo calves . . . also two beaver and one otter."

At the junction of the Missouri and Yellowstone, April 26. "The wide plains, watered by the Missouri and the Yellowstone, spread themselves before the eye, enlivened by the irregular windings of the two rivers, and animated by vast herds of buffalo, deer, elk and antelope. . . . He therefore descended the hills and camped on the bank of the river, having killed as he crossed the plains, four buffaloes. The deer alone are shy and retire to the woods, but the elk, antelope and buffalo suffered him to approach them without alarm, and often followed him quietly for some distance."

Above Milk River, May 9. "As usual we are surrounded by buffalo, elk, common and black-tail deer, beaver, antelopes and wolves."

Above the Great Falls of the Missouri, June 17. "There are vast quantities of buffalo feeding on the plains or watering in the river, which is also strewed with the floating carcasses and limbs of these animals. They go in large herds to water about the falls, and as all the passages to the river near that place are narrow and steep, the foremost are

pressed into the river by the impetus of those behind. In this way we have seen ten or a dozen disappear over the falls in a few minutes. They afford excellent food for the wolves, bears and birds of prey, which circumstance may account for the reluctance of the bears to yield their dominion over the neighborhood."

In the midst of all this abundance the party fed fat. "It requires some diligence to supply us plentifully, for we reserve our parched meal for the Rocky Mountains, where we do not expect to find much game, our principal item of food is meat, and the consumption of the whole 32 persons belonging to the party amounts to four deer, an elk and a deer, or one buffalo every 24 hours." As a general rule they were not satisfied with this modest requirement, and the record abounds with such entries. "The hunters brought in six elk, two buffalo, two mule deer and a bear." They did not even stop with a variety of buffalo beef, mountain sheep mutton, three kinds of venison, and bear meat, besides beavers, prairie chickens, geese and ducks, but "The party killed five elk and a mule deer, and by way of experiment roasted some burrowing squirrels, which they found to be well flavored and tender."

The number, size and ferocity of the grizzly bears along the Missouri River was extraordinary. The black bear, which is common on the lower part of the Missouri, was not seen in this region.

The Lewis and Clark party had frequent encounters with the grizzly bears, and grew to have a wholesome respect for them. The history of one such encounter will suffice.

"Captain Lewis then descended the hill and directed his course toward the river falling in from the West. He soon met a herd of at least 1,000 buffalo, and being desirous of providing for supper, shot one of them. The animal immediately began to bleed, and Captain Lewis, who had forgotten to reload his rifle, was intently watching to see him fall, when he beheld a large brown bear, which was stealing up on him unperceived and was already within twenty steps. At the first moment of surprise he lifted his rifle, but remembering instantly that it was not charged, and that he had no time to reload, he felt that there was no safety but in flight. It was in the open level plain, not a bush or a tree within 300 yards, the bank of the river sloping and not more than three feet high, so that there was no possible mode of concealment. Captain Lewis therefore thought of retreating at a quick walk, as fast as the bear advanced, toward the nearest tree, but as soon as he turned, the bear ran open mouthed and at full speed upon him. Captain Lewis ran about eighty yards, but finding that the animal gained on him fast, it flashed on his mind that, by getting into the water to such depth that the bear would be obliged to attack him swimming, there was still some chance of his life. He therefore turned about, plunged into the river about waist deep, and facing about presented the point of his espontoon. The bear arrived at the water's edge within twenty feet of him, but as soon as he put himself in this posture of defense, the bear seemed frightened, and wheeling about retreated with as much precipitation as he had pursued. . . . He could not conceive the cause of the sudden alarm of the bear, but congratulated himself on his escape, when he

saw his own track torn to pieces by the furious animal."

Above the Gates of the Mountains no further buffalos were encountered, though elk, black-tailed and white-tailed deer, antelopes, mountain sheep, bears and beavers were abundant.

At the headwaters of the Jefferson and on the Salmon River, game was comparatively scarce, though the party managed to get deer, elk, or antelope nearly every day. The Shoshone Indians in this region were subsisting somewhat precariously, obtaining game with much difficulty, and supplementing their diet with roots and fish, while they waited for an accumulation of sufficient forces to enable them to venture across the mountains into the buffalo country, the home of their terrible enemies, the Blackfeet. We have the authority of Lieutenant Bradley for the statement that the Blackfeet subsisted almost entirely on buffalo meat, rarely using antelope, deer, elk, bighorn, bear, or beaver, and scorning fish and wild fowl.

Crossing over the mountains from the Salmon to the Bitterroot Valley, the party still found game in sufficient quantity to satisfy their daily needs; but, with their plunge into the fastnesses of the Bitter-root Mountains over the Lolo Trail, they, for the first time on the entire journey, were unable to procure game. The hunters killed one deer on Packer's Meadows in Lolo Pass, but for six days while crossing the mountains they had no game until Captain Clark killed a wild horse on Obia Creek near the western terminus of the pass. The party suffered severely from hunger, and were obliged to use the last of their scanty supplies of provisions as well as to kill three colts for food.

On their return journey in June of the next year over the crusted snow of the high divide, game was again scarce, though they record, "We saw several black tailed or mule deer, but could not get a shot at them, and were informed that there is an abundance of elk in the valley, near the fishery on the Kooskooskee."

They got one deer at the crossing of Crooked Fork, two at Lolo Springs, and coming down Lolo Creek again entered into a plentiful game country. "We killed six deer, of which there are great numbers, as well as bighorn and elk in the neighborhood."

Compared to the plains and the open valleys of the interior with their marvelous game herds, the heavily timbered country of Idaho and extreme Western Montana has apparently always been relatively poor in game.

Ross Cox, of the Northwest Fur Company, records a trip in November, 1812, from Spokane House up the Clark Fork River to the trading post somewhere near the present town of Thompson Falls. His party fared miserably, living chiefly on horse flesh and boiled rice, and it was not until they got up the river to more open country in the vicinity of Thompson that the hunters got some mountain sheep. The Flathead Indians were depending for subsistence largely on dried buffalo meat obtained on their annual hunt east of the mountains.

Between 1808 and 1811 David Thompson, of the Northwest Fur Company, explored the Kootenai and Clark Fork valleys in Montana, establishing a trading post, Saleesh House, at the

present site of Thompson Falls, and one on Pend Oreille Lake in Idaho. Travel throughout this country was on a somewhat precarious basis, with frequent periods when game was scarce or lacking. In May, 1808, along the Kootenai River near the present site of Bonners Ferry, Thompson's journal records: "May 14. To this date we had the meat of a few small antelopes, but by no means enough to prevent us eating Moss Bread and dried carp, both poor harsh food." The "Moss Bread" was made by the Indians from the tree moss or lichen (Alectoria). "On the 16th we met two canoes, from whom we traded twelve singed musk rats and two shoulders of an antelope, thankful for a change from the Moss Bread, which gave us all the belly ache."

Thompson refers continually to "antelope," by which he probably means the common white-tailed deer, though he may refer to mountain sheep, which should also have been plentifully encountered. Whichever they were, they furnished the principal subsistence in that country. In January, 1810, at Saleesh House, he says, "We made a glacier of shore ice and placed 1,260 pounds of antelope in it." Again, in October, 1811, "All the dried provisions are of Bison meat, and must be carefully kept for the voyage of next summer, so that for the winter we depend for subsistence on the antelopes. They are in sufficient numbers, but the hunting is precarious." Elk were apparently lacking or scarce in Northwestern Montana at that time, as they are rarely mentioned, though they did kill one elk ("red deer") on the Moyie River in Idaho.

The fur-trapping expedition of Alexander Ross in 1823 and 1824 through Western Montana and Idaho presents a graphic picture of game conditions at that early date. Leaving the Northwest Fur Company post at Spokane House in November, 1823, he traveled up the Clark Fork. There were forty men in the party from Spokane House, and he picked up fifteen more in the Flathead country. This motley crew of fifty-five men was composed of two Americans, seventeen Canadians, five half-breeds, twelve Iroquois, and the balance from nine other Indian tribes. Besides the men there were twenty-five women, sixty-four children, and a cavalcade of 392 ponies.

With this multitude to feed, in the dead of winter, no supplies were carried, and they depended on the day's kill of game for their rations. Rarely did the country fail to feed them abundantly. The first few days everybody banged away at the game along the route, but the expenditure of ammunition was so great that Ross prohibited general participation in the hunt, and kept four hunters ahead of the main party.

In the first part of March, 1824, the expedition made camp at Hell Gate, about where Missoula now stands. "In this encampment we remained for a day or two, and our hunters killed 4 wild horses. Just at the time we were starting one morning, and in the act of crossing a dark ravine not far from our camp, about 20 of these beautiful and hardy tenants of the mountains came dashing down from a neighboring height with their shaggy manes and long tails waving in the wind, but with all their keen scent, the rifles of our hunters brought 4 of them to the ground before they had time to turn around. It is a

rare thing for them to be entrapped or approached, and our hunters were more delighted with their success in this little adventure than if they had killed a hundred buffalo. We also got 27 elks and 32 small deer at this place, which secured the party for a while from hunger."

Passing on up the Bitterroot Valley, elk, deer, and mountain goats were very numerous. In Ross Hole, the party, which was held up by deep snow, subsisted for about a month chiefly on mountain sheep, which were abundant in the mountains.

"The big horn sheep party had good luck during several days; but these animals were smaller in size than I had been in the habit of seeing elsewhere, with heads very disproportionate to the size of their bodies, and horns still more disproportionate to the size of the head. The average weight of these animals was 70 lbs., and the head of the male generally weighed as much as a third of the body, while the horns were twice the weight of the head without them. One of the ram's horns brought into our camp measured forty-nine inches in length, following the curve or greatest circle round the convex side; and the circumference in the thickest part was twenty-eight inches. This horn weighed eleven pounds."

If these measurements can be relied on this is an all-time record head.

Ross found buffalos abundant in the Big Hole Basin, and encountered immense herds of them in the Salmon River country in Idaho.

The presence of wild horses in the Western Montana mountains indicates how rapidly they had spread over the West in the less than 300 years since the stock first escaped from the early Spanish conquistadors. Lewis and Clark mention seeing two wild mares and a colt in the Bitterroot, but remark that they were the first they had seen since they left the mouth of the Musselshell.

Wild horses were abundant along the Missouri River. The artist, Catlin, in 1832 gives an interesting description of the wild horses of the plains along the Missouri.

"The wild horse of these regions is a small, but very powerful animal, with an exceedingly prominent eye, sharp nose, high nostril, small feet and delicate leg, and undoubtedly have come from a stock introduced by the Spaniards, at the time of the invasion of Mexico, which, having strayed off upon the prairies, have run wild, and stocked the plains from there to Lake Winnipeg, two or three thousand miles to the north."

He describes a herd on the Red River.

"In the herd we saw all the colors nearly, that can be seen in a kennel of English hounds. Some were milk white, some jet black—others were sorrel, and bay, and cream color—many were of an iron grey, and others were pied, containing a variety of colors on the same animal. The manes were very profuse, and hanging in the wildest confusion over their necks and faces—and their long tails swept the ground."

While the Northwest and Hudson Bay trappers were invading Montana from the West, the fur companies from St. Louis were following closely after Lewis and Clark up the Missouri and Yellowstone. That redoubtable Spaniard, Manuel Lisa, led the way with his post on the Yellowstone in 1809, and

even dared to penetrate as far as the Three Forks of the Missouri, though the Blackfeet made short work of that invasion of their hunting grounds.

Fort Union, built by the American Fur Company about 1830, at the junction of the Yellowstone and the Missouri, became the center of the fur trade in that region. Many naturalists and sportsmen, attracted by the reports of the vast stores of new flora and fauna ascended the Missouri River and enjoyed the baronial hospitality of the fort. The naturalists, Bradbury, Nuttall, and Audubon, have all left us a record of their visits to this region. The two most famous sportsmen who ascended the Missouri in the early days were Maximilian, Prince of Wied, and that eccentric Irish nobleman, Sir George Gore.

Prince Maximilian, a German naturalist and big-game hunter, has left us almost as vivid a record of game conditions on the upper Missouri as Lewis and Clark. In the year 1832 he ascended the Missouri as far as Marias River, just below the Great Falls. His journal is filled with descriptions of the vast herds of game, which were continually in sight. Like Lewis and Clark, the prince had many encounters with ferocious grizzly bears. They were particularly abundant about the mouth of the Milk River. "The true country of these bears is on the Missouri. Where they are at present the most numerous is the tract about Milk River. Here there is no wood of any extent in which they are not found. . . . There is no other species of bear on the upper Missouri, for the black bear is not found so high up."

It is interesting to note that the moose occasionally strayed as far out on the plains as this. "The Moose deer or Original (*Cervus alces Amer.*) is said to be common toward the upper part of the Milk River, and Deschamp himself had killed several of these animals on the Missouri in the vicinity of this river."

The bighorn sheep, which we ordinarily now associate with the high mountain country, was extraordinarily abundant along the upper Missouri in the breaks and bad-land formations. Maximilian saw bands of thirty to fifty at a time.

The Sir George Gore hunting expedition of 1854 to 1856 has given rise to many tales and traditions of that most peculiar and lordly Irishman. His retinue consited of forty men, 112 horses (some very fine ones), twelve yokes of oxen, fourteen dogs, six wagons, and twenty-four carts painted red. He had one wagon loaded with guns and fishing tackle. For his own use he had seventy-five rifles and fifteen shotguns. He slept in state in a brass bedstead, and carried three milk cows to supply his mess with fresh milk.

With this outfit he advanced leisurely across the plains to Powder River, and up the Yellowstone to Tongue River, where he passed the winter. The party is reported to have killed six thousand buffalos at Tongue River.

On his return he built two Mackinaw boats at Fort Union to descend the river. He attempted to sell his surplus goods to the fur-company agent at the fort, but being unable to agree on a price, and feeling that he was being held up, he made a heap of all the wagons and goods and burned the whole outfit, then threw all the iron parts in

the river so that no one could use them.

The thirty years from 1810 to 1840 were the golden age of the Rocky Mountain fur trade. Hardy and adventurous bands of trappers roamed the whole region, and there is not a stream in Montana on which they did not set their traps from source to mouth. While these roaming trappers lived exclusively on the resources of the country, there were not enough of them to appreciably affect the vast game resources, though the introduction of guns, which better armed the Indians, doubtless resulted in a much increased rate of killing.

With the extermination or thinning out of the beaver, the fur trade passed its crest in the forties, leaving little permanent impression on the country except a better knowledge of its geography, which made later settlement and development possible.

Captain Raynolds' military, exploratory expedition of 1859–60 gives us a picture of much country that was still practically unmodified by the white man. His party traveled across the Powder and Tongue Rivers, up the Yellowstone, then south up the Little Big Horn to the Oregon Trail, westward through Jackson Hole, up Henrys River to Henrys Lake, down the Madison to Three Forks, and thence down the Missouri River. He thus completely encircled the site of the future Yellowstone Park, which was not officially explored until the Washburn-Doane expedition of 1870.

Except in the vicinity of the Oregon Trail, apparently no inroads had been made in the game. On the Powder and Tongue Rivers the buffalos had so overgrazed the range that the men were unable to find sufficient pasturage for their mules, and were obliged to cut cottonwood from which the half-famished animals gnawed the bark and twigs. This condition continued through two weeks' travel. Captain Raynolds says, "When my party first reached the bluff overlooking the Yellowstone, the sight was one which, in a few years, will have passed away forever. I estimated that about fifteen miles length of the wide valley was in view. The entire tract of 40 or 50 square miles was covered with buffalo as thickly as in former days in the west (when cattle were driven to an eastern market) a pasture field would be which was intended to furnish subsistence to a large drove for a single night. I will not venture on an estimate of their probable numbers."

Elk, deer, and antelope were found abundantly in the country about Henrys Lake and the Madison basin, and a band of buffalos seen in the high Madison basin, as well as in the main valley below. Down the Missouri River from Three Forks to the Yellowstone, game of all kinds was very abundant, though one gets the impression that there had been some reduction of the vast multitudes described by Lewis and Clark and Prince Maximilian.

Ten years later, in the winter of '69 and '70, my father, Peter Koch, wintered on the Missouri just below the Musselshell, cutting wood for the steamboats and wolfing. Living mostly on meat, he and his companions were able to go out every two or three days, about as one goes to the market now, and bring in a deer or an antelope. His journal records the killing for food that winter of nineteen antelopes, one sheep,

twelve black-tail deer, seven white-tail deer, five elks, and two buffalos. In the spring of 1870 he records a trip across the prairie from the Musselshell to the Little Rockies, when he traveled for three days without getting out of rifle shot of herds of buffalo which blackened the prairie.

The period from 1853 to 1870 marked the passing of the wilderness in Western Montana and the interior valleys of the three forks of the Missouri, the Gallatin, Madison, and Jefferson. The Stevens expedition of 1853 to 1855 was undertaken for the purpose of exploring a route for a Pacific railroad from St. Paul to Puget Sound. Mr. Stevens, with his indefatigable assistants, Mullan, Tinkham, Lander, Doty, Grover, and others, explored the whole mountain region of Western Montana and Idaho. Captain Mullan established a winter base at Cantonment Stevens in the Bitter-root Valley, and by the end of 1855 every valley and mountain pass in the region had been traced out and mapped. As a result of this exploration Captain Mullan's road from Walla Walla to Fort Benton was constructed in 1859 to 1861.

Captain Mullan was an engineer above all things, and the report of his hundreds of miles of wilderness travel is little concerned with game animals or scenery. Road grades and elevations, and economic possibilities of the new country were more in his line. If he ever hunted big game it is not in the record. However, he did drop in an occasional note about the game. He says of the Jefferson River Valley in 1853, "Game here was exceedingly abundant, large herds of deer and antelope being seen, and this is the favorite hunting ground of the Indians, the mountains in the vicinity being filled with large numbers of bear, moose, and elk." Going down the Deerlodge Valley he reports, "Large numbers of antelope were feeding in it, and mountain sheep and goats were seen in the peaks around."

Immediately following Mullan's road development came the discovery of gold at Bannock and Alder Gulch in the early sixties. The lure of gold brought in thousands of adventurous prospectors, and on their heels came the settler, so that by 1870 Western Montana, including the three forks of the Missouri, had definitely passed beyond the pioneer day.

The account of the Yellowstone expedition of 1863, led by James Stuart, is probably the last description of the big game days in the three forks of the Missouri before the tide of gold seekers swept in. Crossing these valleys in April, 1863, enroute from Bannock to the Yellowstone, Stuart records: "Between Stinking Water and Madison, saw elk and sheep; saw plenty deer and antelope on Madison, also twenty elk, black bear, buffalo. In Gallatin Valley saw black-tail, white-tail and twenty elk, plenty geese, ducks and prairie chicken, 4 or 5 black bear. In Bozeman Pass between Gallatin and Yellowstone saw 100 elk, killed grizzly bear."

It is perhaps not generally realized how far Eastern Montana lagged behind the western valleys in settlement. At a time when Missoula, Helena, Virginia City and Bozeman were thriving towns, with stores, restaurants, and banks, and a surrounding of well-developed ranches, the Yellowstone Valley, Judith Basin, and Missouri Valley were still almost primitive wilder-

nesses, teeming with game herds, and guarded by roaming bands of Blackfeet, Sioux, and Crow Indians, who made travel possible only at the risk of life and scalp.

General Edward S. Godfrey is responsible for the statement that in 1876 there was not a ranch west of Bismarck, North Dakota, nor east of Bozeman, Montana.

After the Fort Phil Kearney massacre in December, 1866, the Government ordered all forts abandoned and the Bozeman road up the Yellowstone closed to travel. The Plains Indians, in particular the Sioux tribes, were being crowded westward by the encroaching tide of settlement, and were in no mood to give road to the white man. The Yellowstone Valley and Bozeman Pass, which was the most direct route to the settlements of Montana, was as effectively closed as if it had been locked and barred.

The Custer campaign of 1876 marked the inevitable end of the Indian domination of the country, and in 1883 the completion of the Northern Pacific Railroad definitely put a close to the Montana frontier period.

The extermination of the buffalo herds followed close on the building of the railroad. Theodore Roosevelt, in "Hunting Trips of a Ranchman," writes: "The last of the great southern herds was destroyed in 1878, though scattered herds escaped and wandered into the desolate wastes of the Southwest. Meanwhile, equally savage war was waged on the northern herds, and five years later the last of these was also destroyed and broken up. The bulk of the slaughter was done in the dozen years from 1872 to 1883; never before in all history were so many large wild animals of one species slain in so short a time."

Roosevelt's description of hunting in the vicinity of his Little Missouri ranch in 1885 gives a good idea of the reduction in game by that time. He says, "Five years ago elk were abundant in the valley of the Little Missouri, and in fall were found wandering in great herds of over a hundred individuals each. But they have now vanished completely, except that one or two may lurk in some of the most remote and broken places, where there are still deep wooded ravines." A few scattered buffalos were left, and Roosevelt shot a couple in 1885. The grizzly bear at that time had been completely exterminated in the plains country. White-tailed deer were still fairly abundant in the river bottoms, and black-tailed deer and sheep in the bad lands.

The original range of the buffalo in Montana included all of the plains country in Eastern Montana and all of the open valleys in the West. It is notable that Lewis and Clark did not encounter buffalo west of the Gates of the Mountains on the Missouri. They did not see them on any of the three forks of the Missouri, or in the Bitterroot or Clark Fork valleys. This must have been a temporary condition, since several explorers subsequently report them farther west. Alexander Ross, in March, 1824, found plenty of buffalo in the Big Hole Basin, as did Mullan in December, 1853, and they most likely wintered there. Ross also found large herds along the Salmon River. Captain Raynolds reports buffalos in the Madison Basin and the Madison Valley in 1860. James Stuart saw them in the Jefferson Valley in 1863.

Since the coming of the white man there have apparently been no buffalos west of the Continental Divide in Montana, though they formerly existed there. In Governor Stevens' 1853 report Dr. Suckley writes, "Buffalo were formerly in great numbers in this valley (Bitterroot) as attested by the number of skulls seen, and by the reports of the inhabitants. For a number of years past, none had been seen west of the mountains, but singular to relate, a buffalo bull was killed at the mouth of the Pend Oreille River on the day I passed it. The Indians were in great joy over this, believing that the buffalo were coming back to them."

Dr. Cooper states in the same report in 1860, "I saw one or more old skulls daily in the valley of the little Blackfoot and Hell Gate Rivers, quite down to the junction with the Bitterroot."

The western limits of the buffalo range have been quite generally recognized, but it is less commonly known that the earliest records show an absence of elk in Western Montana and Northern Idaho in many sections where the character of the country would lead one to expect their occurrence. The explorers' records show an abundance of elk all through Eastern and Central Montana as far west as Missoula, through the Wyoming mountains, and west through the upper waters of the Salmon and Snake rivers, and into the Blue Mountains of Oregon.

The Lewis and Clark journals make the definite statement that no elk were seen from the time they crossed the Bitter-root Mountains till they approached the mouth of the Columbia River. On the return journey in May, 1806, the party hunted intensively for a month in the vicinity of the Clearwater River above Orofino without killing a single elk. The journals of David Thompson, Ross Cox, Alexander Ross, and W. A. Ferris, through the period from 1800 to 1830, make no mention of elk in the northwest part of Montana in what are now Lincoln, Sanders, and Mineral counties, or in that portion of Idaho and Eastern Washington north of the Salmon and Snake rivers. The Palouse prairie country, south of Spokane, lacking buffalo and elk, in spite of ideal grass and cover conditions for game, apparently never carried any such riches of game animals as did the Montana prairies.

On the basis of this evidence it seems a fairly sound conclusion that the present elk herds of the upper Clearwater, which winter precariously in the deep snows of the mountains, came originally from the Montana side, from the Bitterroot Valley, and never did winter in the lower country on the west side of the mountains. This may explain why, with the Bitterroot Valley closed to them by settlement, the elk show a reluctance to drift down stream to the west for better winter range.

The theory has been developed, and to a considerable degree accepted by field naturalists, that before the coming of the white man the mountains were very thinly populated with game, particularly elk and buffalo, and that it was only through persistent hunting in the plains and valleys that these animals were driven back in the mountains for refuge. This theory is based to a large extent on Lewis and Clark's record of the scarcity of game in the Bitter-root Mountains, and on a half dozen ac-

counts of early exploration of the Yellowstone Park, from 1870 to 1875.

I am unable to accept this theory. It is probably based on relative rather than actual numbers of game animals in the mountains as compared with the plains country.

To a man accustomed to the daily sight of hundreds of animals on the plains, the ordinary mountain occurrence of game would seem scarcity. James Stuart, in 1863, on the Yellowstone expedition, writes, "Game is getting very scarce. Saw only 3 antelope and 4 elk today." Today the sight of that much game almost anywhere would mark a red-letter day.

Much has been made of Lewis and Clark's semi-starvation while crossing the Bitterroot Mountains. As a matter of fact, this has always been a rather poor game country, and at no subsequent time has game been sufficiently plentiful to enable a large party to "live off" the country. The Lewis and Clark party saw as much game as any later party might have seen on the same route. In the westward journey they got a deer in Lolo Pass and a wild horse on Obia Creek. Coming back in June they saw several black-tailed deer, and state that, "We were informed that there is an abundance of elk in the valley near the fishery on the Kooskooskee." Since the snow still lay deep on the high divides it is possible that these elk wintered along the Lochsa River (Kooskooskee) just as they do now.

In 1893 the Carlin party hunted several days in the best of the elk country on the Lochsa before getting an elk, and nearly starved while going out down the Lochsa River. In July, 1914, I made a month's pack trip in the Clearwater National Forest, including the Lolo Trail, and saw just one deer. One can hardly conclude from these facts that there has been an increase in game numbers in the Bitter-root Mountains since Lewis and Clark's day.

The balance of the argument is based on game conditions described by early explorers in the Yellowstone Park. There are several such records—the Washburn-Doane expedition of 1870, the Hayden survey of 1871, Captain Jones' expedition of 1873, Lord Dunraven in 1874, Captain Ludlow, with George Bird Grinnell in 1875, and others.

Attempts have been made by naturalists to build up the theory from the records of these parties, but the evidence is not very convincing. The Washburn-Doane expedition in 1870, while running rather short on game for the table at times, certainly experienced a general abundance of game. While their journals probably do not mention all the animals they saw, their record indicates the presence of much game. There was a party of fifteen lodges of Crow Indians ahead of them and two white hunting parties in the park at the same time, which may explain a temporary shortage of game along the lines of travel.

"Aug. 26. Killed an antelope. Aug. 24. Saw two bull elk and one bear. Ground tracked by passage of herds of elk and mountain sheep, and bear signs everywhere visible. Aug. 28. Abundance of venison and trout in camp. Aug. 29. Saw black bear. Aug. 31. Saw large flock of mountain sheep in the canyon. Sept. 1. Yellowstone Valley above canyon, elk feeding in small bands. Sept. 6. Yellowstone Lake. The

ground was trodden by thousands of elk and sheep. Bear tracks numerous. Sept. 8. Saw two grizzly bears and two cubs. Sept. 18. Saw fresh signs of buffalo. At head of Snake River found game plentiful and tame, and had no trouble in obtaining an abundant supply."

As a matter of fact, most of these early parties saw much more game than the average visitor to the park would probably have seen in any subsequent years. I have personally made four trips through Yellowstone Park. On the first trip in 1894 we spent a full month in the park, and in 1897 I crossed the park with a pack outfit, from Crandall Creek via Mount Washburn and the canyon to the Gallatin. On neither trip did we see any elk or buffalos, and no considerable quantity of game except antelopes on the Lamar River.

The general statement is correct that the elk and buffalo were primarily plains animals in the sense that they occurred in vastly greater numbers in the plains country, with some timber or mountain shelter, than they did in the higher mountain country, and likewise mountain sheep were far more abundant in the breaks of the Missouri River, or in steep, cliffy country low down along the Clark Fork River than they ever were in the high timberline country. But there is ample evidence that these animals also ranged the high mountain country in probably considerably greater numbers than have occurred at any time since the valleys were settled. In other words, the plains animals were killed off, not driven back in the mountains, and the rough mountain country continued to give some refuge to the animals that were already there.

The early fur trappers recognized a mountain buffalo as distinct from the plains variety. There were doubtless small bands which stayed in the higher mountain valleys the year round. Buffalos were seen in considerable numbers in the Big Hole Basin in early March, 1824, by Alexander Ross, and in December, 1853, by Captain Mullan, so without doubt they wintered in this high, snow-covered valley. Captain Raynolds saw a band in June in the Madison Basin.

Doubtless the elk from the mountains, and also the mule and white-tailed deer, usually wintered lower down than they are forced to do at present by the settlements; and an adequate winter range is now the great problem in perpetuation of the game herds.

It is probable that the period through the nineties and early nineteen hundreds witnessed the lowest level in game numbers through most of Montana. I was brought up in the Gallatin Valley in Montana, and usually spent most of the summer in the hills through the nineties, yet at that time game was so scarce that the sight of a single deer, elk, or sheep was most unusual. I often traveled for weeks, with a pack outfit, through the high mountain country without seeing any big game.

The South Fork of the Flathead and the Sun River country is today considered excellent game country. Deer, elk, and goats are relatively abundant, yet in the fall of 1905 and again in 1906 I rode for a month with pack outfit through the wildest part of that country with a rifle on my saddle, and with the exception of one goat never saw or got a shot at a single big game animal, though grouse were fairly abundant.

With the creation of the National Forests and the cooperation given the State by Forest officers in enforcement of game laws, better general sentiment toward game laws, and the establishment of numerous game refuges, there has been a very considerable increase in game animals in most parts of the State. There is much to be done in the way of more scientific management of game resources, but conditions are distinctly better than they were, and there is now little probability of game species becoming extinct in this State.

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# A TECHNIQUE FOR TRAPPING AND TAGGING SPOTTED SKUNKS[1]

*Wilfred D. Crabb*[2]

Wildlife technicians are constantly confronted with the problem of obtaining certain data without causing atypical behavior in the species studied. It was necessary to deal with this difficulty in the current investigation of the prairie spotted skunk (*Spilogale interrupta*) in Iowa.

For three years the writer has been engaged in research on this skunk over an area of 17 square miles in the southeastern part of the State. The work involves an intensive trapping and tagging program and has required the development and perfection of a trap and of a tagging technique which do not appear to frighten the animals or to have any great effect upon their physical condition.

The spotted skunk is more like a weasel in habits than is the striped skunk, and may be more affected by man's activities. It is rapid moving and can climb trees readily. It is timid but alert and quick-tempered. It is difficult to tame. When kept in captivity for a long period it becomes accustomed to its keeper but may not willingly be touched. The species, too, appears to be more nomadic than the striped skunk (*Mephitis mephitis*) and is probably less inclined to have a permanent den. It is by preference nocturnal and is usually not seen abroad in daylight.

Several types of traps were tried at first, such as those recommended by the United States Biological Survey (now the Fish and Wildlife Service) for the trapping of cats, but they did not prove satisfactory. The trap (Pl. 20-A) finally developed is, to the writer's knowledge, novel in construction and design.

The trap is made like a box with one end double and one side having a swinging door. The side door permits easy cleaning of the trap and setting of the mechanism. This door has a wire cloth insert for admitting light to the interior. All working parts of the trap are inside the box; thus fouling or tripping of the mechanism by snow, ice, water, or wind is avoided. There are no hinges in the tripping mechanism to become stiff during wet weather. There are no places where metal rests against metal or where binding may result, and consequently interfere with the sensitivity and action of the mechanism (Pl. 20-B). The door (an automobile license plate thrice folded) is hung by fishline cord running through eyes fixed in the top of the box. At the trigger end of the cord a ½-inch ring is attached and this ring passes over the wire lever holding up the treadle (Pl. 20-B, and Pl. 21-A). The metal door is heavy enough to counterbalance the treadle and being metal it cannot be chewed.

[1] Journal Paper No. J-822 of the Iowa Agricultural Experiment Station, Ames, Iowa. Project No. 549. Fish and Wildlife Service (U. S. Department of the Interior), Iowa State College, Iowa State Conservation Commission, and the American Wildlife Institute cooperating.

[2] Research in this project is under the supervision of Dr. Geo. O. Hendrickson, Iowa State College, and T. G. Scott, United States Fish and Wildlife Service.

Trap dimensions: width, 6½ inches; length, 16 inches; depth, 10 inches; door opening, (width) 3½ inches, (depth) 3¼ inches; door, (width) 5 11/16 inches,

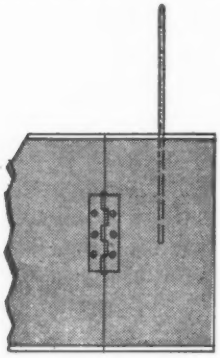

FIG. 1. Right side of tagging end showing the hinge on which the tagging end can be swung away from the chute.

(depth) 4 inches; treadle length, 7 inches; treadle width, 5 inches and wire lever, 2¾ inches.

The door is released by pressure on the treadle which may be adjusted to

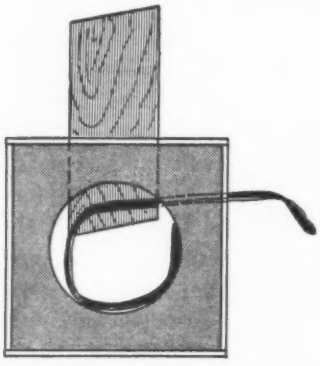

FIG. 2. Front view of chute. Notice that the slide is behind the leather loop.

trip for mice or skunks with equal facility. An automatic metal stop or lock (Pl. 21-A) is placed above the door. This three-cornered piece of metal is so hinged that gravity pulls a point in over the door when the latter comes down.

The trap enables one to approach on the blind side without exciting the captive. Its contents may be investigated by looking through the wire cloth. A gunny sack may be slowly and quietly placed over the open side of the trap without alarming the animal. The skunk in the darkened trap may then be carried in the hands or by automobile any distance without fear of the characteristic, offensive discharge. Removal of

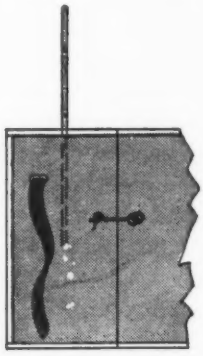

FIG. 3. Left side of tagging end showing the location of the leather strap.

the animal from the trap is easily achieved by putting the trap in direct sunlight. The skunk will leave the lighted trap if a dark box or other place of escape is provided. Another advantage of this trap is that an animal caught in it is partially protected from the weather.

The baits used in this trap were varied with the seasons. Mulberries in summer and wild grapes in the fall were the most successful. Cottontail meat was used during the winter. The traps were smeared with muddy water before using.

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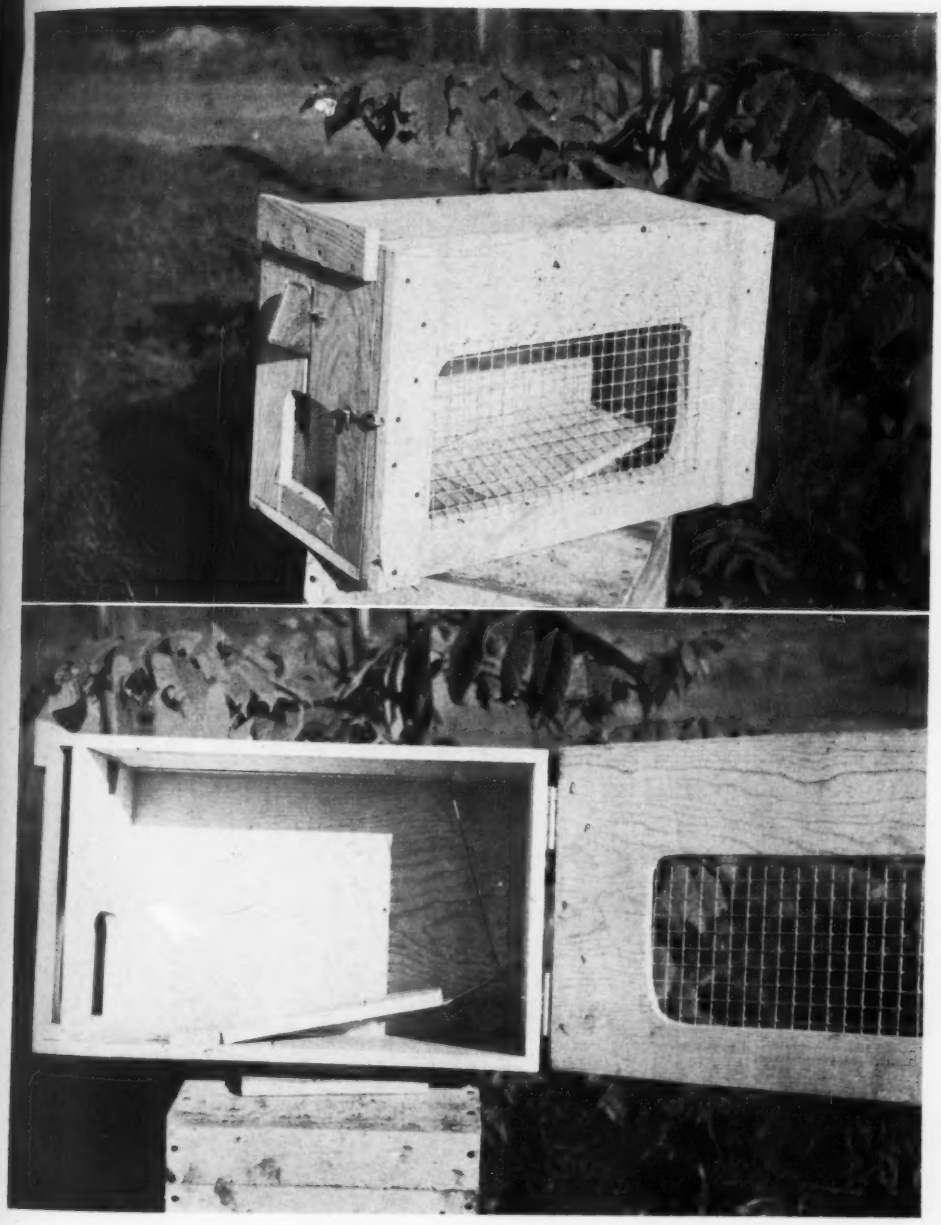
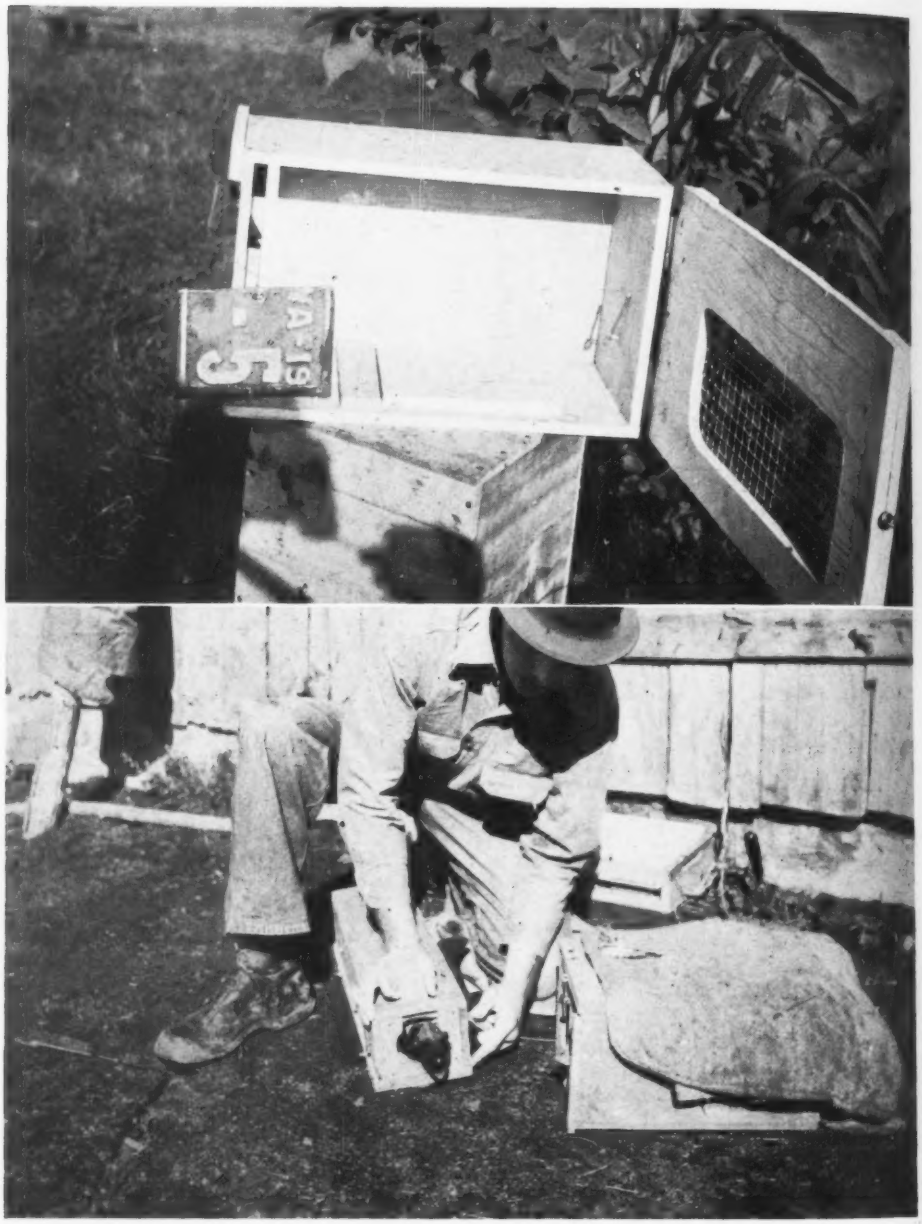
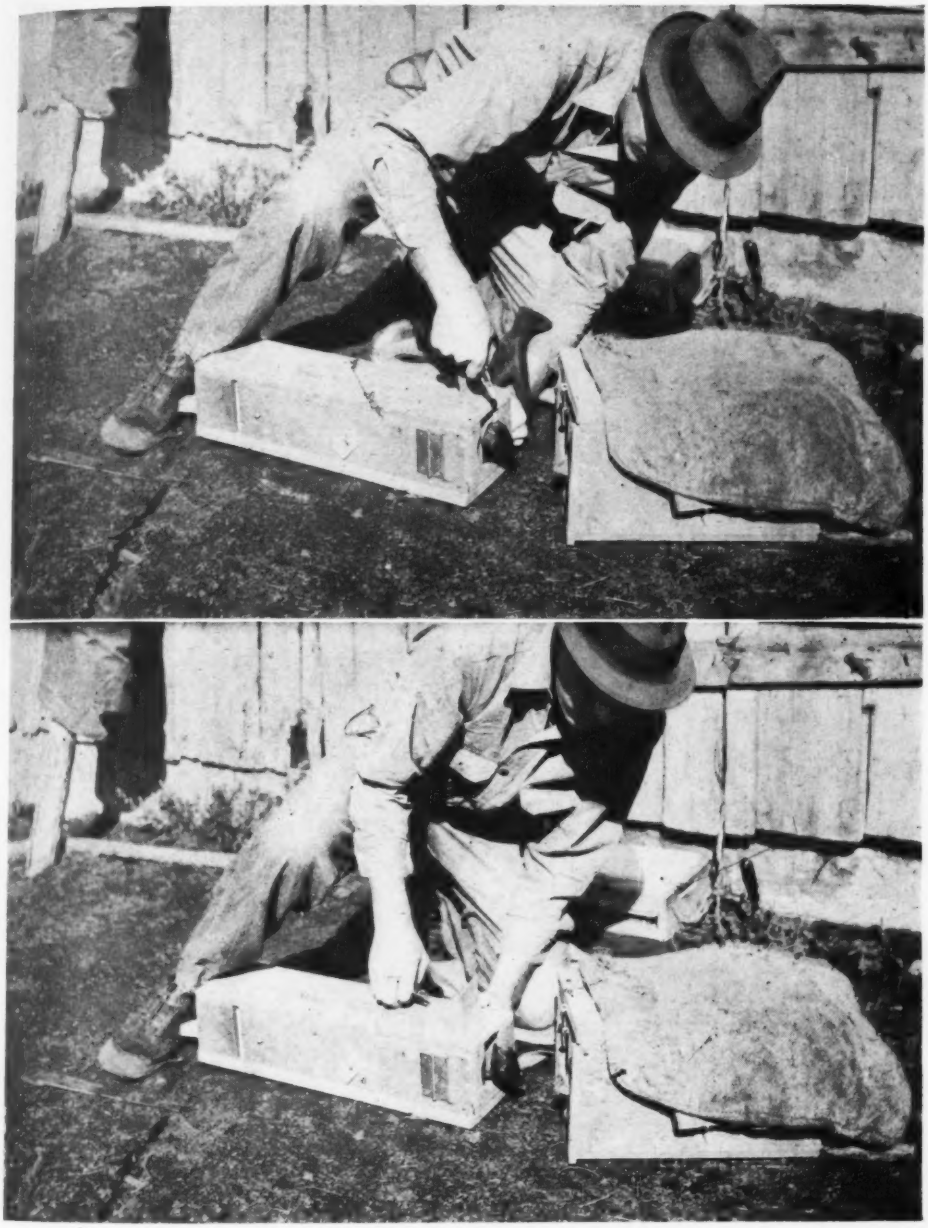


A (*Upper*)—Trap designed and used for the capture and handling of spotted skunks.
B (*Lower*)—Illustrating the tripping mechanism of the spotted skunk trap. Notice that there are no hinges in the tripping mechanism and that it is protected from the weather.

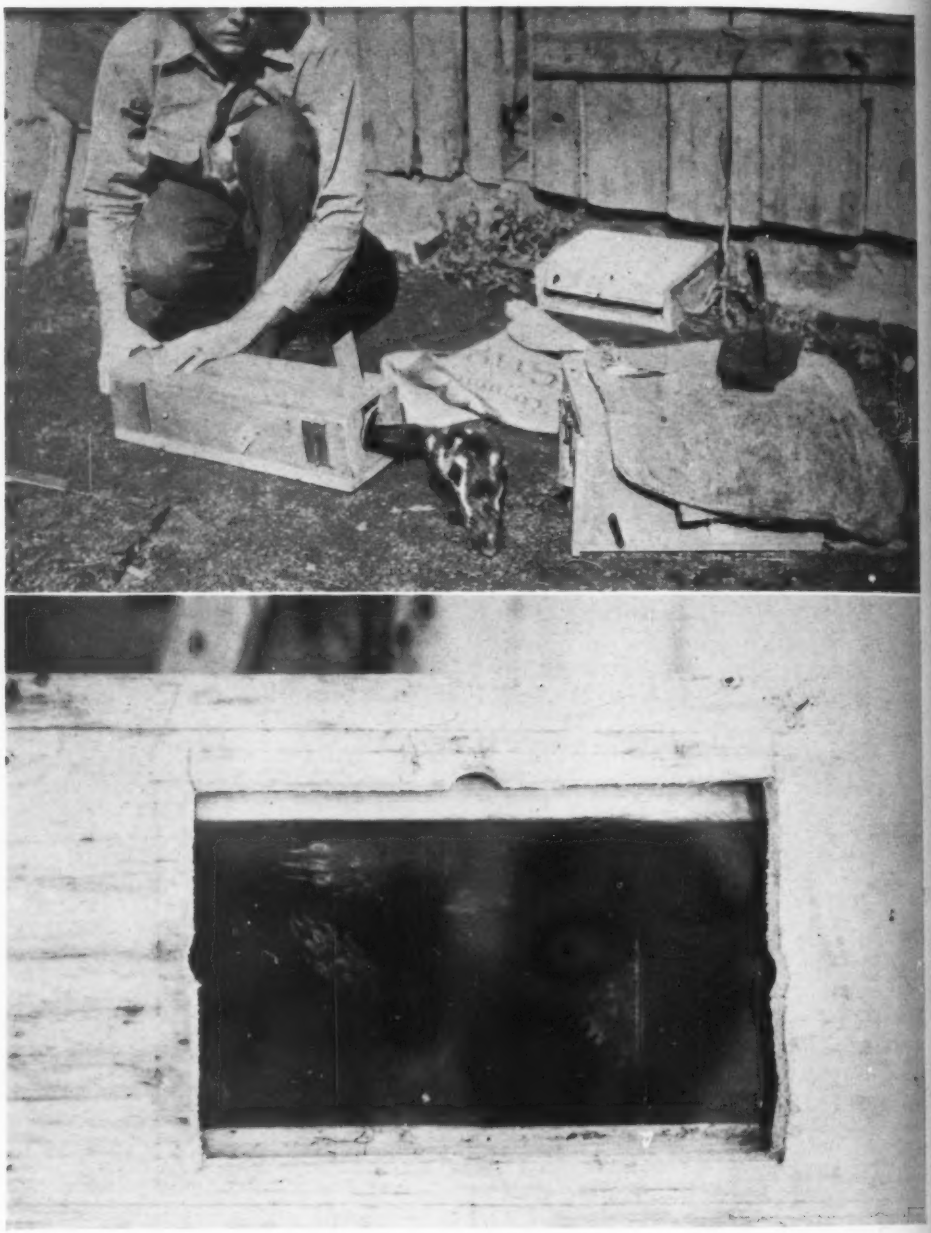


A (*Upper*)—This photograph illustrates the door and lock. Notice how the lock blocks the slot in which the door slides.

B (*Lower*)—The slide in the front of the chute is used to reduce the size of the chute hole and force the animal to struggle thus allowing time for the technician to secure it with the leather loop.



A (*Upper*)—Preparing to place the tag in the right ear of a male spotted skunk. Notice the position of the technician's foot as he holds the wooden block firmly behind the animal.
B (*Lower*)—After tagging the animal; the strap holds it securely.



A (*Upper*)—Releasing the animal. The balance used in this investigation is shown back against the building.

B (*Lower*)—A close-up view of a spotted skunk in the tagging chute. The sex organs of this male were easily seen through the glass but they do not show well in the photograph.

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Ear tagging and sex determination of the spotted skunks after they are caught presented other difficult problems. Attempts to handle the animals in gunny sacks were woefully unsuccessful and use of an anesthetic is not desirable. However, the difficulties were solved by development of an outfit that may be called a tagging chute (Pl. 21-B, Pl. 22, Pl. 23-A).

The animals are induced to enter the dark interior of the chute (Fig. 4) and are then gently pushed up into one end of a low narrow passageway by means of a rectangular wooden block fastened to a two foot handle (Fig. 5). The passageway is so small that the animal cannot turn around and cannot elevate its tail over its back. The block moved slowly from behind soon presses it so securely into one end that it cannot move in any direction. The tagging chute is then turned over and the ventral surface of the animal is viewed through

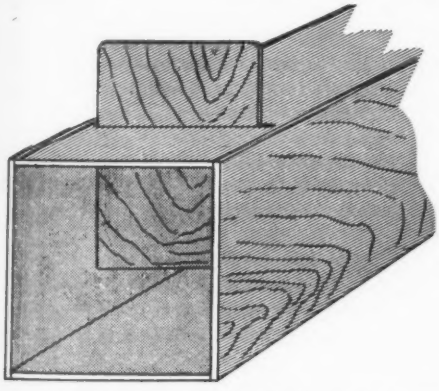

FIG. 4. Back end of chute showing slide used to close chute before the block is inserted.

a plate glass window (Pl. 23-B). The sex may thus be determined and the condition of the sexual apparatus seen. Females with suckling young and females after weaning in the fall may be readily recognized. The feet are also visible in this position, and any deformities, such as those caused by steel traps, can be observed.

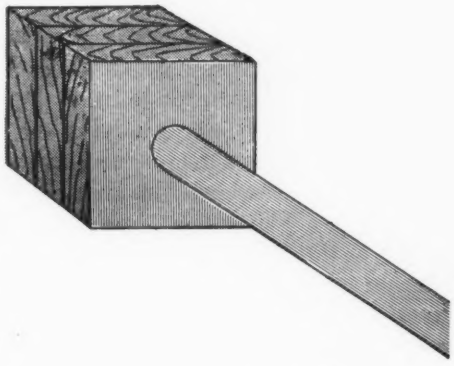

FIG. 5. Wooden block used to push and hold the animal in the tagging chute.

After the sex has been determined and other facts noted, the chute is turned right side up and the slide closing the tagging-end partially opened (Pl. 21-B). The animal's head is then exposed enough to be caught in a leather loop or to be held in a gloved hand while a tag is placed in an ear (Pl. 22 and Figs. 1–3). Males were tagged in the right ear and females in the left.

The tagging chute is constructed of $\frac{1}{2}$-inch pine with adjustable lateral inserts that are used to reduce the size of the tunnel. For adults (males 2 pounds and females $1\frac{1}{2}$ pounds) a wide adjustment of the inserts provides a passageway $3\frac{1}{4}$ inches wide by $2\frac{7}{8}$ inches high. The corresponding wood follow block measures 3 inches wide by $2\frac{3}{4}$ inches high and is the thickness of three one-inch boards fastened together

(Fig. 5). For small animals the passageway is reduced in width by adjusting the lateral inserts. No reduction is made in the height. The reduced tunnel measures $2\frac{3}{8}$ inches wide by $2\frac{7}{8}$ inches high. A follow block of corresponding size is used. The reduction in the chute is needed in the fall when many young animals are caught to prevent them form turning around. In winter, spring, and summer only adults have been caught and a rectangular block and chute of standard size have been satisfactory. The working end is attached to the chute by a hinge and can be swung out of the way if an animal gets in backwards and will not come out. In that case it can be forced out by running the block through from the tagging end.

Approximately 75 spotted skunks have been tagged in this chute and not one of them has been able to pollute the operator with scent. Most of the animals handled made no discharge whatever. In careless hands the animal may discharge a small amount of scent inside the chute before the block is closely fitted behind it. If the animal is pushed out of the chute rather than allowed to leave of its own accord (Pl. 23-A) after tagging, it may also offend. Occasionally exceedingly nervous individuals, especially those that have had frequent experiences with dogs, will discharge inside the chute after being ear tagged and the pressure from behind is released. Even so it is impossible for the animal to spray the operator. The animals are not harmed in this apparatus and are seldom frightened. The whole operation can ordinarily be done in less than half an hour and one man can easily do it alone.

Weight is determined by weighing the tagging chute with the animal in it and later deducting the weight of the chute. For this purpose a balance with a flat top on which to set the chute is used (Pl. 23-A).

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# FALL AND WINTER MORTALITY AMONG HUNGARIAN PARTRIDGES IN BOTTINEAU AND McHENRY COUNTIES, NORTH DAKOTA

*Merrill C. Hammond*

In connection with fall and winter studies of the resident game species on the Lower Souris National Wildlife Refuge, North Dakota, covey counts of Hungarian partridges were made in 1938–39 and 1940–41 for the purpose of estimating mortality and determining the adaptability of this species to winter conditions in the agricultural districts of McHenry and Bottineau counties in north central North Dakota, within which the refuge is situated. Counts were not restricted to the refuge but were made throughout the two counties.

The major part of this region is devoted to grain farming, but there is a considerable acreage of native grass and waste land. Corn growing has received increasing attention in recent years, since failure of wheat crops, the prevalence of lower prices, and the development of livestock production have prompted some of the farmers to diversify their crops.

Graded and graveled roads are important locally to the welfare of Hungarian partridges. They provide the only supply of grit ordinarily available during the winter months, and probably much of that obtained at other seasons. When the snow is deep the windswept roads are apparently utilized also as feeding areas. Covey counts along roads satisfactorily sampled the population, there being a decided tendency for the partridges to include a graveled, or at least a graded, road within their winter range, especially during periods of moderately deep snow.

Although counts were made in all partridge habitats, the majority were made on or near roads. Covey counts were not taken during the winter of 1939–40. There was very little snow (3 to 6 inches) until the latter part of February and partridges were not nearly so dependent upon graveled roads as they were in 1938–39 and 1940–41.

Of 85 partridge deaths or injuries noted during the period from August, 1938 to March 11, 1941,[1] 68 were attributable to automobiles, 10 were the result of injuries caused by collision with telephone, power, or fence wires, and 6 the result of collision with either automobiles or wires. In this period one bird was killed by a prairie falcon. During the winter of 1937–38 a snowy owl was flushed from a freshly-killed partidge.

Golden eagles and snowy owls were the most common winged predators on areas frequented by partridges. One or two golden eagles hunted regularly over grain fields near refuge headquarters each winter. Probably not more than four snowy owls wintered on the refuge during any one year, and but few were seen elsewhere in the two counties. These birds, and also mammalian predators, probably contributed to winter losses of the partridges.

The weight and general appearance of partridges found dead along highways compared favorably with those of birds trapped for banding at feeding stations. Even during periods of deep snows and

[1] Hunting season mortality excepted.

extremely low temperatures, all partridges examined were in very good physical condition, while pheasants in the same localities were often found to be thin and sometimes, apparently, were starving.

### FALL AND WINTER MORTALITY

Estimation of winter mortality is based upon the trend of average covey sizes for the fall and winter months of 1938–39 and 1940–41.

When accurate counts could not be obtained, usually with the larger coveys, an estimate of the number of birds was made. The estimated counts are believed to compare closely with the actual number of birds in the coveys and, since the exclusion of the large coveys would tend to give undue weight to the smaller covey sizes, all estimates were included in this study.

Partridges on some areas frequently traveled by refuge personnel were counted several times each month and it was believed that the tabulation of these would make the data more representative of a restricted locality than of the larger area. It was found, however, that elimination of the frequently-counted coveys did not materially change the monthly average covey sizes, so all counts were used.

Eleven single birds and 12 pairs were recorded but were omitted from tabulation, since they could not be classed as true coveys. Single birds had probably become separated from coveys as a result of some unusual disturbance, such as might have been caused by a predator. All but one of the pairs were seen either in October or February. The October pairs may have been birds unsuccessful in raising a brood, and the February pairs probably resulted from exceptionally early mating attempts.

Hunting season mortality was greater during the fall of 1940 than during the previous study year. The season was opened on upland game birds between October 1st and 21st, 1940 and there was a daily bag limit of 5 partridges. In 1938 there was a 10-day open season and a bag limit of 5 birds, not more than 3 of which were to be of one species (partridge, pheasant, or grouse). This was conducive to the taking of the larger kinds.

There was some mixing of birds among coveys with overlapping territories and some temporary division of coveys. When several coveys used the same feed patch or stretch of road, it was found that the number of birds in each group might vary from time to time, even though the total number for all remained the same. For example, 44 birds on one area were flushed as 7, 9, 13, and 15 birds per covey. At later visits they were found in groups of all sizes from 6 to 14 birds.

As mentioned later in the report, covey sizes increased slightly in October or November, probably as the result of combination between pairs with broods and unsuccessful adults. There was an increase in average covey size from November to December, 1940, possibly due to combination of coveys during a period of cold weather and deep snow.

It is believed that, although division and combination of coveys occurred and were a source of error in the study, they did not occur frequently enough to materially affect the validity of the data used. Combination of coveys would tend to compensate for division of other coveys. It is therefore thought that

A (*Upper*)—Stubble field, weed patch, farm grove, and graveled road. This habitat provided winter range for three coveys of partridges in 1940–41.

B (*Lower*)—Waste grain (durum wheat) left in the field after harvesting. Note the pigeon grass (*Setaria viridis*), a good partridge food, growing with the grain.

TABLE 1

AVERAGE COVEY SIZE OF HUNGARIAN PARTRIDGES IN BOTTINEAU AND McHENRY COUNTIES, NORTH DAKOTA, 1938–39 AND 1940–41

| Period | Number of covey counts | | Number of birds counted | | Average covey size | |
|---|---|---|---|---|---|---|
| | 1938–39 | 1940–41 | 1938–39 | 1940–41 | 1938–39 | 1940–41 |
| Brood counts | 8 | 79 | 104 | 928 | 13.00 | 11.75 |
| September | 16 | 27 | 202 | 272 | 12.62 | 10.07 |
| October | 12 | 113 | 150 | 1,156 | 12.50 | 10.23 |
| November | 16 | 50 | 204 | 470 | 12.75 | 9.40 |
| September, October, and November | 44 | 190 | 556 | 1,898 | 12.64 | 9.99 |
| December | 22 | 26 | 239 | 257 | 10.86 | 9.88 |
| January | 33 | 46 | 348 | 398 | 10.55 | 8.65 |
| February | 44 | 120 | 445 | 985 | 10.11 | 8.21 |

change in covey size through the period studied was a fairly accurate measure of mortality.

Counts were discontinued after February 21, 1939 and February 26, 1941, as pairing began shortly after those dates.

Winter conditions are quite variable in the portion of North Dakota studied, and years of relatively mild weather as well as those of extreme cold occur. Even though the snow was 20 inches in depth at times (in areas protected from drifting), winds kept it piled in drifts, and the stubble fields had a covering that averaged not more than 5 or 6 inches (Plate 24). Field observations disclosed that partridges were able to dig through these snow depths and find waste grain. The lowest temperature was minus 46° Fahrenheit (unoffcial record), and during February, 1939, the thermometer was above zero on only thirteen days.

The amount of waste grain in the fields was somewhat greater than normal in 1938–39, when grasshopper infestation and hail storms prevented complete harvesting of crops.

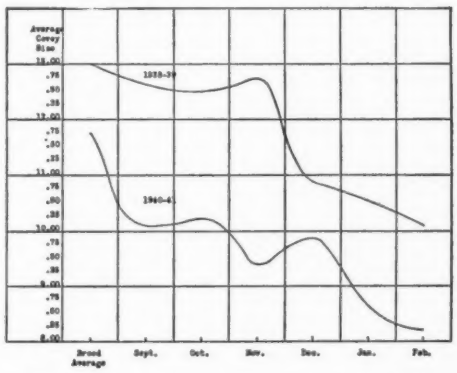


Fig. 1. Average Hungarian Partridge covey size. Bottineau and McHenry Counties, 1938–39 and 1940–41.

The average covey sizes for the period between September and February, 1938–39 and 1940–41 are given in Table 1, and from this, Figure 1 was prepared. The brood averages were obtained from 8 brood counts made in July and August, 1938 and 79 made during the same months in 1940.[2]

[2] North Dakota Pittman-Robertson project leader Stanley Saugstad furnished 57 brood counts taken in Bottineau and McHenry counties by Fish and Game Department workers during July and August, 1940.

Comparison between covey sizes for the two years disclosed the following:

1. Brood size and monthly averages were smaller in 1940–41 than in 1938–39. There was a greater decline between brood average and February average in 1940–41 (0.65 greater).

2. There was a larger drop between brood average and September average in 1940–41 than in 1938–39, probably the result of higher juvenile mortality in 1940–41.

The factors responsible for the smaller brood size and increased juvenile mortality in 1940 could not be definitely determined. In 1940, precipitation averaged 1.54 inches greater during the five months from April to August than in 1938, and was 1.43 inches greater during May and June, 1940 than during the same months in 1938.[3] Wet weather is recognized as a factor causing losses of young bob-whites (Stoddard, 1931) and of young partridges (Maxwell, 1911). Yeatter (1934) found evidence that wet weather combined with certain soil conditions resulted in mud-balling of young chicks. Predators, diseases, parasites, or accidents may have contributed to the losses.

3. The increase in the average covey size between October and November, 1938 and September and October, 1940 may have been due to combination of broods and unpaired and unsuccessful adults.

4. There was a fairly large decrease in 1940 between October and November averages, probably due largely to hunting season mortality and some division of coveys. Lower shooting mortality and possibly inadequate sampling may have prevented a decrease from appearing in 1938 data.

5. November to December averages showed a large decrease in 1938, but an increase of .48 birds per covey in 1940. The temperature was much colder during late November and the first part of December, 1940 than in 1938 and may have resulted in combination of small coveys, thus accounting for the increase. Part of the increase may be due to insufficient sampling in December, 1940.

6. A decrease is shown both years for December to January averages, but it was much less in 1938–39 than in 1940–41. The temperature was colder in January, 1941 than in January, 1939, but there was no increase as with November to December averages.

7. There was a decrease both years in the January to February averages. Temperatures were somewhat colder in February, 1939. Total snowfall to the end of February, 1939 was 21.2 inches at Bottineau and 27.5 inches at Towner; to the end of February, 1941 was 14.6 inches at Bottineau and 33.0 inches at Towner, but had settled to about 12 to 20 inches on areas where no drifting occurred.

8. From Table 2 it may be seen that the decrease in covey size between the brood average and the February average was 7.9% greater in 1940–41. The decrease between the brood average and the fall average was 12.2% greater in 1940–41, and the decrease between the fall and February averages was slightly greater (2.2%) in 1938–39.

[3] Obtained from average precipitation of Bottineau (Bottineau County) and Towner (McHenry County) weather records. April to August, 1938, 12.29 inches; 1940, 13.83 inches. May and June, 1938, 4.70 inches; 1940, 6.13 inches.

TABLE 2

DECREASE IN AVERAGE PARTRIDGE COVEY SIZES IN 1938–39 AND 1940–41, BOTTINEAU AND McHENRY COUNTIES, NORTH DAKOTA

| | | *1938–39* | *1940–41* |
|---|---|---|---|
| Decrease, brood average to fall average | birds | .36 | 1.76 |
| | % | 2.8 | 15.0 |
| Decrease, fall average to Feb. average | birds | 2.53 | 1.78 |
| | % | 20.0 | 17.8 |
| Decrease, brood average to Feb. average | birds | 2.89 | 3.54 |
| | % | 22.2 | 30.1 |

## COMPARISONS BETWEEN COVEYS COUNTED ON OR NEAR MAIN ROADS AND ELSEWHERE

The figures in Table 3 compare the average size of coveys frequenting areas near graveled roads upon which automobiles normally traveled fast enough to kill partridges, and of those on tracts not within range of main roads or highways.

TABLE 3

HUNGARIAN PARTRIDGE HIGHWAY MORTALITY. JANUARY AND FEBRUARY AVERAGES COMBINED FOR 1938–39 AND 1940–41

(Number of counts in parentheses)

| *1. Coveys near highways* | | *2. Coveys elsewhere* | |
|---|---|---|---|
| *1938–39* | *1940–41* | *1938–39* | *1940–41* |
| 9.72 (29) | 8.16 (130) | 10.65 (48) | 9.08 (36) |

The average January-February size for class "2" was .93 and .92 greater in 1938–39 and 1940–41, respectively, than the average for group "1."

It was possible to obtain a dependable sample of highway mortality on five miles of highway between Upham and a point two miles south of Kramer, North Dakota. This road was traveled frequently by refuge personnel and it is believed that most of the birds killed were found. Eight coveys of partridges (79 birds in February) were known to get gravel on this road in 1938–39. Between August, 1938 and February, 1939 fourteen partridges were found, all of which appeared to have been killed by automobiles. Nine of the deaths were the result of a car hitting a covey of juveniles on August 18. Including these, the average loss was 1.7 birds per covey.

Between September and March, 1940–41, a maximum of 16 coveys (136 birds in February) obtained gravel from this same stretch of road. During this period 17 partridges were found. Thirteen had been killed by automobiles 3 by collision with telephone or power wires, and one by contact either with automobiles or wires. The loss to automobiles was .81 and the total loss, 1.06 birds per covey.

Considering that roads are practically the only source of grit over most of the two counties, and in view of the local data as to highway mortality, it would appear that automobiles, and also wires, are important hazards for the birds.

## COVEY SIZE OF FED PARTRIDGES

In an attempt to determine the extent to which standing grain and feeding stations might reduce mortality, comparisons were made between the average size of coveys wintering near catered food supplies and of coveys in localities where only stubble fields or natural foods were available (Table 4). To avoid the influence of highway mortality, only counts made away from main roads were used in this tabulation.

It will be noted that the average size of "other coveys" was .56 larger in 1938–39, but that of "fed coveys" was .49 larger in 1940–41. From this data it does not appear that winter feeding of Hungarian partridges was necessary

TABLE 4

JANUARY-FEBRUARY AVERAGE SIZE OF FED AND OTHER COVEYS, 1938–39 AND 1940–41.

| | Number of coveys | | Number of birds | | Average size | |
|---|---|---|---|---|---|---|
| | 1938–39 | 1940–41 | 1938–39 | 1940–41 | 1938–39 | 1940–41 |
| Fed coveys | 32 | 16 | 338 | 147 | 10.56 | 9.19 |
| Other coveys | 16 | 20 | 178 | 174 | 11.12 | 8.70 |

to insure high survival during the two winters studied.

No instances of starvation or malnutrition of these birds have been noticed or reported since 1935, when refuge personnel first began observations.

Game shelters were visited during severe storms and low temperatures, and with one exception, no evidence was found that they were of any utility in protecting partridges from inclement weather. On February 10, 1939, one shelter and feeding station was inspected during a strong northwest wind when the temperature was between minus 20° and 25°F. It was occupied by three partridges and eleven pheasants, but it was impossible to determine definitely whether the birds were there to get protection from the wind or had come for feed and gravel.

Leaving strips of standing wheat or corn close to adequate escape cover would be useful as a precaution against food shortage when exceptionally deep, heavy snows occur, and against cover deficiency in years when there are invasions of snowy owls or other winged predators.

## PARTRIDGE PLANTINGS IN NORTH DAKOTA AND POPULATION DENSITY

According to information obtained from the North Dakota Game and Fish Department and from Burnie Maurek, who was Game and Fish Commissioner, during the most extensive partridge plantings, the following releases of the birds have been made in the state:

| | |
|---|---|
| 1915 | 50 pairs |
| 1923 | 50 pairs |
| 1924 | 200 pairs |
| 1924–1930 | 1,307 pairs |

The results from these plantings have been augmented by influx of birds from Alberta, Canada, where stockings were were made in 1908, 1909, and after 1922.

The general population density in the two counties during the period of study was not determined, but some of the areas within a few miles of the Lower Souris Refuge supported as many as three or four coveys to the section (about 16 to 20 acres per bird) during the fall and winter. The maximum number of counts made along two 25-mile stretches of highway in McHenry county averaged a covey to a mile in February, 1941.

Although brood averages and covey sizes were smaller in 1940–41 than in 1938–39 it appeared that 1940 fall densities throughout the two counties were as high, or a little higher, than in 1938.

On three of the best game areas on the refuge, which included standing grain fields or feeding stations and supported a mixed population of partridges, pheasants, and grouse, Febru-

ary 1939, partridge densities were as shown in Table 5.

TABLE 5

PARTRIDGE DENSITIES, LOWER SOURIS REFUGE

| *Location* | *Approximate acreage* | *Number of partridges* | *Acres per bird* |
|---|---|---|---|
| Sec. 4, T159N, R78W. | 200 | 44 | 4.5 |
| Sec. 23, T159N, R78W. | 160 | 46 | 3.5 |
| Sec. 17–20, T160N R78W. | 480 | 90 | 5.3 |

Certain English manors with 4 acres per bird in the spring, approaching 1 acre per bird during the fall (Maxwell, 1911) illustrate densities of population on well-managed areas. Yeatter's (1934) results during a March census on study areas in Michigan were 4.4, 11, and 13.3 acres per bird.

## PARTRIDGE MANAGEMENT

From the data here presented, it would appear that partridges are well adapted to ordinary winter conditions in the area studied, and that their population densities in the agricultural districts may be materially increased by management practices similar to those carried out on certain refuge areas where a population at or near the saturation point has been attained.

It is probable that providing for the following requirements of the birds would yield worthwhile results in filling some of the many gaps in North Dakota which, because of unsuitable environment, are now devoid of partridges.

*Cover.*—There is a decided deficiency in the amount of escape cover on most of the farm land. The establishment of tall, dense, and fairly extensive brush, weed, or grass cover patches along fence lines, in potholes, and at other locations would be of considerable value. They should be within a short distance of winter feeding areas. Caragana, Tartarian honeysuckle, chokecherry, wild plum, Russian olive, silverberry, and several other shrubs are well adapted to this use in the area. Standing sweet clover furnishes excellent winter cover. An undisturbed grass or weed fringe would provide good early nesting cover, a facility now limited mainly to roadsides and overgrazed farm woodlots. Natural cover with an accumulation of dead growth has been found to be most suitable for nesting (Hawkins, 1937).

*Food.*—Under ordinary winter conditions, waste grain and weed seeds appear to suffice for maintenance of the birds. As a precaution against the hardships of deep snow and cold, or against an abnormal predator population, standing grain (durum wheat or corn) might be left near cover patches. Yeatter (1934) found that partridges in Michigan utilized uncut corn fields extensively for cover as well as for food. Many of the common weeds provide valuable winter partridge foods.

*Gravel.*—Many apparently suitable areas will not winter partridges unless provision is made for supplying gravel and keeping it available. At present the birds obtain most of their supply from graveled roads which serve only a relatively small percentage of the agricultural districts. Piles of gravel near feed and cover, and so placed that winds will keep them free from snow should suffice and they might tend to reduce highway mortality among the partridges.

*Nest predators.*—Heavy skunk and crow populations have been found to be very destructive to the nests of ground-

nesting birds in the area. Where an attempt is being made to increase the number of partridges, skunks and crows should be kept at a low level. Yeatter (1934) found evidence that the common house cat frequently killed females upon the nests.

## SUMMARY

1. Fall and winter covey counts of Hungarian partridges in McHenry and Bottineau counties, North Dakota, form the basis of this paper.

2. Automobiles, elevated wires, and predators were the factors known to be responsible for winter mortality.

3. An average loss of 2.89 and 3.54 birds per covey (22.2% and 30.1%) was found between the brood and February average sizes in 1938–39 and 1940–41 respectively.

4. Highway mortality was found to be .93 and .92 birds per covey in 1938–39 and 1940–41. On a sample, five-mile stretch of road, mortality due to automobiles was about 1.7 birds per covey in 1938–39 and .81 bird per covey in 1940–41. The loss due to both automobiles and telephone and power wires was 1.06 birds per covey in 1940–41.

5. The average size of fed coveys was not consistantly larger than that of coveys subsisting on natural foods and waste grains, and it is believed that, in this area, winter feeding of partridges is not necessary to insure high winter survival under ordinary conditions.

6. A summary of partridge plantings in North Dakota is given. Sample population densities on the area studied are included for comparison with those of other partridge ranges.

7. Suggestions for partridge management are presented.

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# LIGHT-INDUCED EGG-PRODUCTION IN LARGE PENS FOLLOWED BY NORMAL NESTING IN PHEASANTS[1]

*Thomas Hume Bissonnette and Albert George Csech*

In previous studies on forcing early egg-production in Ring-neck pheasants by night-lighting, small pens and five or fewer hens to a cock were used. Lighting from December 16 onward induced production of fertile eggs by mature birds beginning on January 15. Birds hatched on May 7 and only 185 days old were stimulated to lay a few fertile eggs from November 8 onward. Chicks from these eggs hatched on Christmas day and, without artificial lighting, produced two infertile eggs on July 25 and 26 of their first summer. Lighting, begun in January, caused birds to lay many fertile eggs before April 1–4, the opening of the normal breeding season. On return to normal days and larger cages with abundant cover, these birds, after a short break, resumed laying in April, May, and June at a slower rate than before. In the first experiment of this sort no nests were built; the later eggs were laid here and there on the floor and were not fertile. Second trials in the next year, with Ring-neck, Black-neck, and Mongolian pheasants resulted again in random laying by Ring-necks, after return to normal days and cover, and no nests. Black-necks, after some scattering of eggs, deposited twelve eggs in a nest and began incubation. Mongolians, also after parallel behavior, built two nests and started brooding the twelve and thirteen eggs in them. The hatch from these eggs after transfer to hens was high (Bissonnette and Csech, 1936a, b, 1937, 1938a, b, 1939).

The evidence that Ring-necks could not be induced to lay fertile eggs in nests after return to normal days, good cover, and larger pens, following forced egg-production under lights, was not convincing. In view of the economic importance of the matter, experiments were planned to determine the effectiveness of larger pens and more hens, up to eight or more, per cock.

## Materials and Methods

Square pens, 12′×12′, with sides and top of chicken-wire netting and a baseboard three to four inches high, were used. A roosting pole was placed across one corner of each pen about eighteen inches from the ground. Straw was scattered over the sand floor, and feed boxes and grit were provided; but no cover of any sort was available for the birds to hide in or to prevent snow from falling or drifting into the pens. A 100-watt light-bulb, with reflector, was hung in the center of each cage, just high enough to shed light up to eighteen inches above the floor at the middle of each side of the pen, and slightly lower at the corners. This arrangement prevented the experimental birds from hiding from the direct rays of the light (Plate 25).

[1] Aided by a grant from the Penrose Fund of the American Philosophical Society, 1938–39, and by birds and care furnished by the Connecticut State Department of Fisheries and Game.

Three groups of birds were subjected to night-lighting in such cages; 1♂+6♀♀, Mongolians; 1♂+8♀♀, Ring-necks; 1♂+5♀♀, Black-necks. One group of 1♂+8♀♀, Ring-necks, in a similar cage (and all of the remaining pheasants of all varieties at the sanctuary, over fifty in number) served as controls without experimental lighting.

Night-lighting was begun on January 3, with one hour each night for the first week. This was increased by one hour each week to six hours per night and held constant until April 25, when it was stopped. Pine branches were then piled against the walls to about three feet in height in two corners of each cage, as cover for the birds, and more straw was spread on the floor for nests.

Eggs were collected frequently to prevent freezing; for they were often dropped in the snow (Plate 25). When birds froze into the ice around the edges of the pens at night, as they did frequently in cold weather, they were broken out in the morning. Some lost tail feathers by pulling free before they could be reached. Altogether this constituted a most rigorous test of the method used, as against the inhibiting effects of cold and other inclemencies of the weather.

Otherwise care and food were the same for both experimentals and controls. The latter had plenty of cover throughout the period of the study and did not need to be broken out of ice.

## OBSERVATIONS AND RESULTS

Controls began to lay as usual, about the first week in April or later, depositing random eggs about the pens for a time, then building and laying in nests, and finally starting to incubate. This sequence appears to be the normal one for pheasants in the wild. Sometimes more hens than one laid in the same nest and some hens continued to lay in a nest after one had begun to set on the eggs.

Experimental birds behaved as follows:

Mongolians (1♂+6♀♀ to April 8, then 5♀♀) began to lay on February 20, with 2 eggs. The rate reached five eggs a day on March 5. Forty-three eggs were laid in the nine days of February. Fourteen of these were eaten (or perhaps a few more, without trace). The birds stopped egg-eating, however, without preventive action by those in charge. In March, 143 eggs were laid, to the number of six in one day only twice. In the first 25 days of April, 103 eggs were laid, six in one day only once. One hen died on April 8. In all, 289 eggs were laid through April 25, when lighting was stopped, an average of 53.7 eggs per bird. Before April 5, the beginning of the normal breeding season, 207 eggs had been laid, an average of 34.5 eggs per bird.

Ring-necks (1♂+8♀♀) began on February 19, with one egg. The laying rate reached four per day on the 24th and 27th. Seventeen eggs were laid in February, of which several were eaten. Clipping of the birds' bills on March 1 stopped this practice. In March, 160 eggs were laid, with seven per day on the 9th and eight on the 15th, only. In the first 25 days of April, 123 were laid, making 300 to that date, and 200 before the 5th, the first laying date of the controls, an average per hen of 25 before the regular season, and of 37.5 under lighting. Since some eggs may have been

Flashlight photograph of pheasants in cage under night-lights in February, showing the positions of the birds, the light, and eggs laid in a hollow in the snow under the light.

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eaten without trace, this calculation is conservative.

Black-necks (1♂+5♀♀, to March 22, and 4♀♀ afterward) began to lay on February 13 with one egg. The rate per day reached three on the 28th and, on March 1, bill-clipping was required to stop egg-eating. Twenty eggs were laid in February. In March, before the 22nd, when one hen broke her neck flying against the wire, 54 eggs had been laid, to the number of five per day only on the 19th. The five hens, to that date, had averaged 14.8 eggs per hen. During the remainder of March, 31 eggs were laid by four hens. In the first twenty-five days of April, 66 eggs were deposited, bringing the average per hen up to 39.05, and to 25.8 per bird before the beginning of the normal season on the 5th.

In all the groups, some hens began to scoop out cavities in the straw and lay eggs therein before April 25, at which date, however, random laying still occurred. In February and early March, when there was considerable snow and cold weather, hollows formed in the snow beneath each light and some birds laid their eggs in these by day and even under lighting at night (Plate 25). Experimental birds in all three pens often became frozen into the ice formed at night from snow melted around the base-boards by day, and had to have their feathers and feet freed in the morning. Although laying went on in spite of this, it fluctuated with the weather, being inhibited by severe conditions. Fewer eggs were laid after the beginning of severe weather and for a day or two even after milder weather returned. This effect, however, was merely a modifying one, superimposed upon the more fundamental activation by increase of day-length. It did not prevent laying but retarded it.

Incubation of random samples of early eggs, set on April 3 in a not very dependable incubator, gave the following results:

Mongolians, 50 eggs set; 35 fertile; 18 hatched.
Ring-necks, 50 eggs set; 33 fertile; 22 hatched.
Black-necks, 23 eggs set; 12 fertile; 0 hatched.

Irregularity in action of the incubator was probably the cause of the poor hatch.

After return of the birds on April 25 to normal day-length and abundant cover, results were as follows:

Mongolians (1♂+5♀♀) continued to lay three or four eggs each day until May 1. Then laying fell off gradually to no eggs on May 13, 14; one on the 15th; none until the 22nd, and one each day to the 25th. Then eggs were left in the pen to encourage nesting. From April 26 to May 25, inclusive, 45 eggs were laid, an average of nine per hen, and from the latter date to June 19, 84 eggs, or 16.8 per hen, were deposited, all at random on the floor. No nests were made, although in the previous year under similar conditions two nests, with 12 and 13 eggs, were made by this breed and fertility was high.

Ring-necks (1♂+8♀♀) laid four or five eggs each day for nine days after April 25. Then production fell off to one egg a day on May 9, 10, 11, 15, and to two on each of the intervening days. It rose again to four, three, and two after the 18th. The birds laid 87 eggs, 10.9 per hen, through May 25. Eggs were

then left in the pen to stimulate nesting and 110 eggs, 13.75 per hen, were laid up to June 19. Two nests were made. Incubation began in one, on twenty eggs, on May 24, and in the other, on fifteen eggs, May 28. It is significant that Ring-necks, building no nests in two previous years with somewhat similar treatment, did lay eggs in nests and begin incubation.

Black-necks (1♂+4♀♀) laid at their usual rate, up to three eggs per day, until April 29. The rate then fell off to none on May 4, and one or two a day until the 18th, when again none was laid. It then rose to four a day on the 20th and decreased to one on the 25th. This gave 51 eggs, 12.75 per hen, up to May 25, when eggs were left in the pen. Forty-one eggs were laid before June 19, 10.25 per hen. Incubation was begun on one nest of nine eggs on June 7.

Settings of 224 eggs on April 30 yielded the following results:

Mongolians: 82 eggs set; 73 fertile; 11 hatched, May 24 and 25.

Ring-necks: 72 eggs set; 58 fertile; 7 hatched, May 24 and 25.

Black-necks: 70 eggs set; 50 fertile; 15 hatched, May 24 and 25.

The poor hatch was probably due to lack of moisture in the incubators.

The fertility and hatch from eggs laid in nests were:

Ring-necks: 20 eggs; 17 fertile; 0 hatched. 15 eggs; nest abandoned; 3 eggs moved into another nest. Hens disturbed too much by cock.

Black-necks: 9 eggs; 7 fertile; 4 hatched. All lived.

No appreciable harm appeared to have been done to the experimental birds by their forced laying or by their second laying period.

## DISCUSSION AND CONCLUSIONS

An analysis of the performances of these birds under night-lighting and after return to normal length of day and to cover, expressed in eggs per hen-day, after laying began with each group, reveals interesting trends (Table 1).

TABLE 1
CHANGES IN EGG-PRODUCTION PER HEN-DAY

| *Dates* | *Mongolians* | *Ring-necks* | *Black-necks* |
|---|---|---|---|
| Under lights | | | |
| February | 0.796 | 0.212 | 0.350 |
| March | 0.715 | 0.645 | 0.566 |
| April 1–25. | 0.780 | 0.615 | 0.660 |
| Before normal season | 0.760 | 0.555 | 0.512 |
| Whole lighting period | 0.762 | 0.491 | 0.525 |
| Normal days | | | |
| April 26–30 | 0.600 | 0.575 | 0.600 |
| May 1–25 | 0.240 | 0.320 | 0.390 |
| May 25–June 19 | 0.672 | 0.550 | 0.410 |

The data indicate that, although an individual Black-neck hen was the first to lay, the Mongolians on the average were the quickest starters and maintained laying best under both sets of conditions; they were most affected by reduction of the daily period of lighting. They also showed the best recovery after the break in laying. Ring-necks, this year, were the poorest layers under lighting. Their rate of laying, after reduction of light, fell off less than that of Mongolians, more than that of Black-necks, and later than that of either of the others (nine days as opposed to seven for each of the others). After return to normal days they were second in production and best for nesting, with Mongolians poorest (no nests). Last year, under somewhat similar conditions, Mongolians made two nests, Black-

necks one, and Ring-necks none: this year, Mongolians none, Black-necks one and Ring-necks two. The three groups are therefore equal as to nests built for the two years. This indicates that there is little difference between them in respect to nesting after return to normal days. These conditions, of course, only approximate those the pheasants would meet if released into the wild and better performance may occur on release, with crowding and disturbance reduced.

The results here reported, and experience with controls and other birds and conditions, indicate that eight hens may be used effectively with one cock. Feather-picking is considerably less prevalent with larger pens and more birds in a pen.

Attempts to nest in the straw before reduction of lighting furnish evidence that, with larger quarters and even without cover, pheasants tend to abandon random laying and to lay in nests. All three groups did this. The laying of eggs in hollows in the snow beneath the lights was a manifestation of the tendency.

The slowing up of laying during and after severe weather shows that other factors, besides length of day, affect the rate of deposition of eggs. The weather factor, however, is not powerful enough to offset entirely the more fundamental one of day-length. Influences found by others to modify this rate are: (1) For some birds that nest in flocks, the number of other pairs nesting and courting in the neighborhood (Darling, 1938); (2) for pigeons, the sight of another bird of either sex or of the bird's own image in a mirror (Matthews, 1939); (3) for the song-sparrow, temperature and time of year (although how the latter can be divorced from day-length is difficult to see) (Nice, 1937). Without these stimuli the final stages of maturation and laying of eggs may fail to occur in birds otherwise ready for breeding activity. Other cases have been discussed by Marshall (1936), Bissonnette (1939), Ringoen and Kirschbaum (1939), and others. Even small boys know of the effect of the number of eggs left in the nest upon continuance or cessation of laying in the Flicker and other birds, including the domestic fowl. The early stages of sexual activation in many female birds appear to be conditioned (accelerated or retarded) by the light cycle acting through the eyes, while the very latest stages require other factors for completion. Among these, weather or temperature must be reckoned for pheasants.

The results so far achieved indicate that it is possible and economically advantageous to obtain many fertile eggs in late winter and early spring, well before the normal breeding season, by controlled lighting. As the birds resume breeding activities after return to normal length of day, it is probable that the stock, used for early "forced" egg-production, "planted" in the wild in the normal breeding season will renew laying and nesting and incubate a fair number of clutches with reasonably good hatch and rearing. This second breeding in the wild costs the State or "planter" nothing; and survival of the "planted" birds and their offspring will probably closely approximate the carrying capacity of the areas used.

With good incubators and brooders, adapted for pheasants, or with broody

hens, there appear to be good prospects of lowering considerably the cost of producing and rearing pheasants for restocking depleted areas. The use of larger pens and more hens per cock is advantageous in reducing the breeding stock required and in allowing more attention to be paid to production of a superior type of bird by rigid selection for both breeding and field performance.

## SUMMARY

(1) Mongolian, Ring-neck, and Black-neck pheasants were night-lighted from January 3 to April 25 in pens 12′×12′, without cover, then returned to normal days and abundant cover.

(2) Controls, without lights, had cover throughout and began to lay on or after April 5.

(3) Of experimentals, Mongolians began to lay, February 20; Ring-necks, 19th; and Black-necks, 13th; averaging 0.760, 0.555, and 0.512 eggs per hen-day before the normal breeding season, from date of first egg, and 0.762, 0.491, and 0,525 through April, respectively, with fair fertility.

(4) Eggs were laid in depressions in the snow even when birds became frozen into the ice on the floors at night and required breaking out in the morning. Nest-making was attempted by all groups before April 25. Severe weather reduced laying but did not stop it, indicating that it is a factor in the later stages of breeding, not in the fundamental activation.

(5) On return to normal days and cover, laying was maintained for 7, 9, 7 days, respectively, for the different breeds; dropped off to 0 for varying periods, and was resumed at a slower rate by all groups. Nests made were 0, 2, 1, as compared with 2, 0, 1, respectively, in the previous spring.

(6) Mongolians were the best layers, most affected by reduction of light, made best recovery in laying; but made no nests this year. Ring-necks were the poorest layers, least affected by reduction of lighting, made second best recovery, and two nests this year, none last year.

(7) Eight hens may be used effectively with one cock in pens, 12′×12′, to obtain early light-induced eggs; and breeding stock may then be "planted" in the wild in April with fair to good prospects of rearing broods at no further cost for care and keep.

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# WILDLIFE BORDERS—AN INNOVATION IN FARM MANAGEMENT

*Verne E. Davison*

The methods of land management followed by a farmer are usually similar to those of his neighbor. Mutual problems are commonly encountered, crops are generally the same, and the arrangement of crop fields, woodlands, and pastures fit into the landscape in ever-recurring design. But agricultural patterns change as knowledge accumulates concerning unusual plants, soil conservation practices, and related factors that affect the use of land.

The retirement of submarginal lands is a popular subject of present day agricultural discussion. The useful employment of waste or idle land is always good farm economy. The adaptation of vegetation suitably selected for erosion control is one of the goals sought by most agencies dealing with land management, both private and public. Even so, a narrow strip of land that is indeed submarginal, waste, and idle, occurs on the borders of all cultivated fields adjoining woodland throughout the Southeastern States. The total length of these borders for a single county may exceed a thousand miles. Since they are all potential wildlife habitats and the strips cannot be used for crops, wood products, or grazing, suitable vegetation is being selected and established on them for wildlife. They are, therefore, referred to as wildlife borders.

A wildlife border is actually a combination of a travel lane and food patch for animals, and of improvement of edge redesigned to solve the farmers' troublesome problem of maintaining profitable cropland adjacent to woody plants. Aldo Leopold called the wildlife border "an almost perfect example of putting wildlife, farming, erosion (control), and forestry together in a technique acceptable to all."

It exemplifies the cardinal principle of wildlife management in agriculture that any measure to be applicable widely must be acceptable to the average farmer. A wildlife improvement practice to be acceptable to the farmer must be simple in application and should contribute tangible values to the farming operations.

The establishment of wildlife borders is not intended as a complete game or wildlife management plan for a farm. The border is merely one of the factors that deserve recognition. There is great need for habitat improvements that are acceptable to large numbers of farm operators. The improved field border has earned the distinction of being acceptable to more farmers in the Southeast than any other agricultural practice of benefit to wildlife, because it is of immediate practical value to the land to which it is applied. It is approved not only by farmers but also by agronomists, foresters, agricultural engineers, soil specialists, land-use economists, and wildlife conservationists.

Wildlife borders have been developed progressively in the Southeastern Region of the Soil Conservation Service over a period of about 5 years. From trials, observations, successes, and failures a satisfactory practice has emerged.

## THE PROBLEM

Most southern farms were cleared from forest land and since the climate favors the reestablishment of woody plants by natural seeding or by root suckering, control of such renewal must be maintained if a farmer is to continue the cultivation of his fields. The trees on the woodland edge not only sap the adjoining cropland and thus prevent profitable crop production, but when cultivation is discontinued, new trees and shrubs become established on the the retired strip. To prevent the field from steadily diminishing in size, the custom has been to cultivate a crop on the border of the field even though a profitable yield was not expected.

Border erosion is severe because of the lack of ground cover and is further intensified by surplus water collecting at the ends of contour rows. Work stock and farm machinery, which are frequently driven around the edges of fields, pack the soil and increase the run-off.

The eroding field border frequently develops into an active gully. Then complete abandonment is necessary and the farmer retreats to a new line of defense. These ugly scars are particularly offensive to the farmers because they are constant reminders of wasted land, labor, and materials.

The three evils—tree encroachment, erosion, and loss of the use of the land—are purposely mentioned first because they are usually recognized by farmers as immediate problems needing correction. The desire for wildlife lies dormant except with a small proportion of the farmers who will improve the borders for the sake of wildlife alone.

The field-border problem area is rather uniformly 30 to 35 feet wide, measured from the trunks of trees of average size at the edge of the woods. This width and location suffice for the development of useful wildlife shelter and food to replace the barren, eroded strip left by customary farm management. Plants used on this area, however, must be selected carefully to accomplish the following purposes:

1. They must resist, or if possible, prevent, the establishment of trees that would extend the woodland edge or its effects farther into the field.

2. They should be capable of continuous maintenance with little labor and expense.

3. They must stand up under the occasional passage of farm machinery and work stock, and under the wash of water discharging from the ends of contour rows.

4. They should be attractive in appearance.

5. They should provide types of cover and food for wildlife that will supplement those dependably available nearby.

## THE TREATMENT

Experience shows that *Lespedeza sericea* most nearly fulfils all of these requirements, except in the deep South where as yet no plant has been found that is altogether satisfactory. Sericea, therefore, is recommended for improving field borders in Virginia, North Carolina, South Carolina, Georgia, Alabama, and Mississippi, except on the Coastal Plain which includes the longleaf and slash pine belts and Florida. Four other perennial lespedezas—*L. juncea*, *latissima*, *bicolor*, and *cyrtobotrya*—appear to have considerable promise in the northern part of the region—

and possibly in the southern part where sericea has not yet proved its adaptability.

Numerous other native and introduced plants have been found unsatisfactory due generally to their inability to grow aggressively in partial shade in competition with tree roots. Failure to protect the soil from erosion, and inability to reseed or otherwise continue permanently on the site, are additional reasons for failure.

Fig. 1.—Map of the southeastern States. The shaded area shows where *Lespedeza sericea* is being used successfully for the herbaceous portion of wildlife borders. It probably is suitable also in adjoining areas to the north and west. A similar plant is needed farther south where sericea grows less vigorously.

The following wildlife border recommendations apply to the area indicated by the shaded portion of the map (Fig. 1). They may prove suitable also for adjacent districts to the north and west, and properly modified, may apply to areas farther south.

A border of *Lespedeza sericea* of uniform width (approximately 15 feet) is seeded to form the edge of the cultivated field. Paralleling the sericea strip and immediately adjacent to it on the woodland side, a 20-foot border of native shrubs is encouraged to full development by the removal of any trees that may be suppressing the shrubs. The combined width (35 feet) of the two elements of the wildlife border is the average distance over which trees usually prevent the profitable production of commercial crops.

The widths of either the herbaceous or the shrubby parts of the border, or both, can be varied to suit field conditions and the needs of the land owner. The sericea strip is sometimes widened to 20 or narrowed to 10 or 12 feet and the shrub strip may vary in width from 15 to 25 feet. Narrower widths are usually inadequate to provide permanent defense of crops against tree encroachment and wider strips are wasteful of land and are uneconomical to maintain.

The development of the shrub border by release cutting is not practical if a full stand of trees is present, or if hardwoods predominate in the woodland edge. In such cases, it may be established by planting a strip located just beyond the woodland; however, widespread acceptance of such shrub border planting cannot be expected until direct seeding methods are well developed. One of the greatest needs is for a shrub that can be seeded to produce a complete stand in three years; a problem on which work is now being done.

The wildlife border should continue the full length of the adjoining woodland and cropland and should be de-

Sapped borders of cultivated fields adjoining woodland are present on thousands of farms in every southeastern State. Unprofitable cultivation is commonly practiced to prevent the reestablishment of trees on the borders. The use of legume-, grain-, and row-crops in strips, as shown in the lower picture, provides considerable food for wildlife, but without a permanently vegetated border, neither soil conservation nor wildlife conservation is completely served. Whole fields of a single crop, as shown in the upper photograph are even less protective of soil and wildlife.

Wildlife borders fill the unproductive strip between trees and cultivated crops as shown in the upper picture. A 15-foot strip of *Lespedeza sericea* prevents shrubs from suckering into the field, and a 20-foot band of shrubs takes up the remainder, thus preventing trees from growing nearer than 35 feet to the crop. Escape cover, nesting sites, travel lanes, small fruits, and an emergency legume thus become available to wildlife where otherwise there is a useless edge.

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veloped progressively through the years. The herbaceous portion must be maintained free of shrubs and the shrub border free of trees which, when mature, would sap the cropland fertility even across the herbaceous border.

A lighter type of wildlife border—having less appeal to farmers at this time but having similar wildlife advantages—is the combination of a shrubby hedge, or stream bank, with narrow strips of sericea.

Another type of wildlife border that has proved desirable to some farmers but is of less value to wildlife is a 10- to 15-foot border of *Lespedeza sericea* alone developed on the edge of cultivated land next to pastures or grassed waterways, to restrain Bermuda grass from encroaching upon the field.

Two illustrated leaflets[1] are available for those who desire detailed specifications for establishing field borders on Southeastern farms.

The wildlife border has won recognition because it fits into the farm pattern without interfering with either the beauty or the usefulness of the farm; indeed, it enhances both. The farmer becomes more interested in wildlife because the habitat developed for it has aided him materially in solving a discouraging land management problem. The permanency of the wildlife border, assured by multiple values to the land operator, is an outstanding point in its favor. A border supplies substantial protection for farm game, standing guard against the elements, man, and predators, day and night, throughout the year.

[1] Leaflet No. 188, USDA, Protecting Field Borders. Leaflet No. 200, USDA, Shrubs for Wildlife on Southeastern Farms.

Certain questions about field and shrub borders have been raised by hundreds of farmers. Agronomists, foresters, entomologists, engineers, economists, and game technicians also have added their questions. A few of the more frequent queries are discussed in the following paragraphs.

1. Is sericea a preferred wildlife food? At present only a tentative reply can be made. Bob-whites and juncos are known to have eaten the seeds. Rabbits cut considerable numbers of stems in the fall but whether they eat seeds, leaves, stems, or any of them, is not certain. Annual lespedezas (common Korean, or Kobe) rank higher in preference (and abundance) for bob-whites in the Southeast, but crop rotations that are adequate for the conservation of soil call for the maintenance of from one-fourth to one-half of the acreage in annual lespedezas every year—an amount far beyond the needs of quail. Sericea on field borders probably has its greatest value for game birds and animals as a type of shelter and as a travel lane providing access to the annual lespedezas, waste grains, weed seeds, and insects of the field. When snows, occasional invaders of the South, do come, all annual lespedezas are covered and it may be that sericea is then fully welcomed as a food. Partial study indicates that sericea is probably more palatable than native perennial lespedezas such as *L. virginica, capitata, frutescens,* and *hirta.*

2. Won't the farmer harvest the sericea for hay or seed? Yes, in some, but probably not in most, cases. It is not economically feasible to cut sericea for hay because of the narrowness of the strip, and it is unwise to reduce its

erosion-control value or to weaken its ability to resist shrub encroachment. The herbaceous border, in competition with tree roots, usually will not yield high quality hay or a harvestable quantity of seed without a greater application of fertilizer than is required for the same plant when grown in a hay field free from sapping. The border need not be cut, since most farms have sufficient land suitable only for hay that can better be used.

3. Why not use annual plants? The strip must prevent shrubs, trees, and Bermuda grass from becoming established in the border and thence interfering with the crop. This effect is more important than wildlife benefits in the farmers' processes of evaluation. Annuals have but temporary ability to resist such invasion, whereas sericea, once established free of trees and shrubs is able to delay woody growths for years. No decline in this vigorous resistance has been observed in borders six years of age. For some soils in the coastal Plain, partridge pea (*Chamaecrista fasciculata*), Florida beggarweed (*Desmodium purpurea*), and Augusta vetch (*Vicia angustifolia*) are promising annuals.

4. Will farmers cut out valuable trees to make room for wildlife shrubs? No, if the trees are valuable and not ready to market and the cost of cutting can not be justified. However, a tree loses much of its value if it is close enough to cultivated crops to cause damage.

5. Isn't the job of maintaining a shrub border too difficult? No, the work required becomes less and less each year as the shrubs mature and it is always less than that involved in the usual practice of cutting both trees and shrubs along field margins. As soon as shrubs are dense enough to utilize completely the available sunlight and soil nutrients, tree seedlings can rarely become established.

## SUMMARY

Methods of land management are changing and the wildlife border is becoming a part of the new land-use patterns of southeastern agriculture. Particularly needed between woodland and cropland, the vegetated strip is designed for multiple use, including turnrow, erosion control, water disposal, control of trees, beauty, and wildlife food and cover.

The recommended border for the area shown in Plate 26—consists of two parts—a strip of *Lespedeza sericea* next to the crops and a strip of shrubby vegetation next to the woods. The herbaceous portion must be maintained free of shrubs and the woody portion free of trees.

The border serves wildlife as shelter —nesting sites, travel lanes, roosting and resting areas, and escape coverts. Emergency food is also provided by *Lespedeza sericea* and woody plants such as the sumacs, honeysuckle, grapes, haws, blackberries, and dogwoods, and cedars, wild cherry, and persimmon, of low growth.

The wildlife border is acceptable to most farmers because of its simplicity, its easy maintenance, and its multiple values. An increased interest in wildlife results from this tangible contribution to better farm management.

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# THE EFFECT OF REVEGETATION ON THE SMALL BIRD POPULATION IN ARIZONA

*Gale Monson*

It is generally considered that conservatively grazed areas in southwestern ranges support denser bird populations than do those heavily grazed. This supposition was tested when the author took a census of small birds on a controlled grazing area and on an adjacent uncontrolled one in northern Arizona, and found that increased food and cover on the managed tract had the apparent effect of more than doubling the small bird population. These areas and the census methods and results are the subject of this paper.

The plots studied were in and adjacent to Steamboat Demonstration Area, about 17 miles west of Ganado, on the Navajo Indian Reservation in northeastern Arizona. The Bureau of Indian Affairs, in cooperation with the Soil Conservation Service, established the Demonstration Area, consisting of 24,526 acres, or about 38 square miles, in order to demonstrate range improvement through controlled grazing and water-spreading practices. The portion censused was one square mile, and consisted of two 160-acre plots inside the Demonstration Area, and two of equal size outside the Area (Fig. 1).

Before the demonstration tract was fenced and placed under control in the summer of 1936, it was one of the most severely eroded parts of the Navajo Reservation. Most of it was crossed by deep, narrow gullies, which at the time of the census, July 1938, had not shown much tendency to fill or become revegetated. Places badly deteriorated by sheet erosion, however, had been revegetated to a considerable degree and soil loss had been materially reduced.

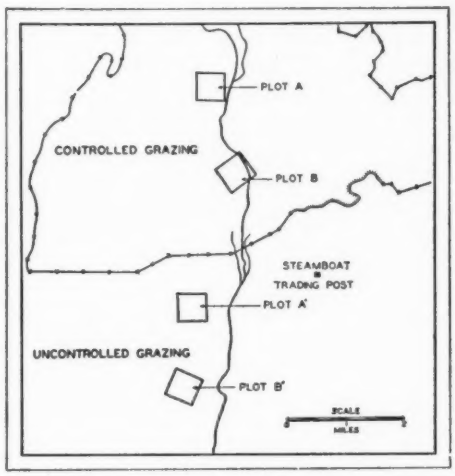


FIGURE 1

At the time the Demonstration Area was put under management, erosion in the vicinity of the outside plots was not as severe as inside the Area. Moderate gullying was noted, however, as well as some sheet erosion.

Before the Area was closed, it had for many years been severely overgrazed by livestock, principally sheep. Under management, the number of livestock has been held at carrying capacity. The outside plots long had been, and were still being overgrazed at the time of the study.

Range conservation practices that had been put into effect on the Demonstration Area included construction of several large, and numerous smaller,

water-spreading dams and adoption of proper grazing practices. A number of woody plantings were made, and although survival in places was good, the plants were too small to provide much cover for wildlife. Practically all of the increase in cover as well as in the total volume of vegetation was due to the regulated grazing and water-spreading. There was no treatment of the outside area, including the two check plots.

At the time of the census, the Demonstration Area showed remarkable vegetative recovery. This was especially true where flood water had been diverted from gullies and spread over adjacent land. The surviving vegetation had recovered rapidly and increased, both in volume and density. The vegetation of the two 160-acre plots inside the Area was composed of mixed grass-browse, mostly chamise and wheatgrass with some winterfat, and was representative of cover inside the Demonstration Area.

Western wheatgrass (*Agropyron smithii*), in places, had established a pure stand of high density. Formerly barren areas were becoming well covered by winterfat (*Eurotia lanata*). The most common browse species on the Area, chamise (*Atriplex canescens*), was not spreading, but the amount of foliage and consequent wildlife shelter per plant was considerably heavier.

The plots outside the Demonstration Area were so selected that their vegetation resembled as nearly as possible that of the census plots on the controlled Area in their overgrazed condition. Such vegetation consisted of scattered chamise, mixed with snakeweed (*Gutierrezia sarothrae*), and remnants of galleta grass (*Hilaria jamesii*) and blue grama (*Bouteloua gracilis*), most of which was being heavily grazed at the time of the census.

The two plots inside the Area will be referred to as Plots A and B, and those outside as Plots A′ and B′ (see map, Figure 1). Plot B′ was censused in the afternoon of July 13; Plot A′ in the forenoon of July 14; Plot B in the afternoon of July 14; and Plot A in the forenoon of July 15, 1938. Weather conditions were similar each of the three days on which the censuses were made. It will be noted that a forenoon and an afternoon census was taken in each of the two general areas, to eliminate effects brought about by the time of day.

Corners, centers, and quarter mile distances on each 160-acre square plot were marked by laths with white flagging. In making the actual census, the following procedure was used: Three men worked together, in 250-foot lanes. The man on the left, or on the right, according to the direction of progress, set up flagged lath markers every 300 feet to indicate one boundary of the lane, using a compass to keep a straight line. The center man was responsible for identifying and recording all birds seen, and covered the strip between the other two men in zigzag fashion. The third man removed the laths used to mark the other side of the lane. In this manner the territory was thoroughly covered, and it is believed that few birds were either missed or duplicated. The method appears to be well adapted to a mixed grass-browse country, where the cover is not heavy. About four hours were required to census each 160-acre plot.

The data obtained (Table 1) indicate that increased cover and food in the Demonstration Area had the effect of

more than doubling the small bird population. This statement is conservative as Plots A′ and B′ had better vegetative cover than did Plots A and B before the Demonstration Area was set up. It is realized that four plots do not constitute an entirely satisfactory sample, but the difference in the bird populations between the conservatively grazed and the overgrazed plots was so great, more than 100 per cent, that the findings are considered significant. It cannot be stated definitely, but it is believed, that the population increase was largely due to the cover factor, and to a lesser extent, to the increased food, both plant and insect, that had become available.

For one species, the results are very striking. The western meadowlark requires good grass cover, and is, therefore, a rare bird on the Navajo Reservation, in general. In the Steamboat Demonstration Area, however, it was common. The census revealed 49 individuals in Plots A and B, but none in A′ and B′. Increase in vegetation appears to be the only possible explanation of this great discrepancy.

TABLE 1
CENSUS DATA

| Bird Species | | Inside Area | | | Outside Area | | |
|---|---|---|---|---|---|---|---|
| | | Plot A | Plot B | Total | Plot A′ | Plot B′ | Total |
| Sparrow hawk | Falco sparverius | | 2 | 2 | 1 | | 1 |
| Mourning dove | Zenaidura macroura | 1 | 8 | 9 | | 8 | 8 |
| Cassin's kingbird | Tyrannus vociferans | | 1 | 1 | | | |
| Ash-throated flycatcher | Myiarchus cinerascens | | | | 1 | | 1 |
| Say's phoebe | Sayornis saya | | 1 | 1 | 1 | | 1 |
| Horned lark | Otocoris alpestris | 8 | 28 | 36 | 30 | 4 | 34 |
| Rock wren | Salpinctes obsoletus | 11 | 5 | 16 | | | |
| Mockingbird | Mimus polyglottos | 2 | | 2 | | | |
| Bendire's thrasher | Toxostoma bendirei | 7 | 4 | 11 | 1 | 3 | 4 |
| Sage thrasher | Oreoscoptes montanus | 19 | 2 | 21 | 2 | 8 | 10 |
| White-rumped shrike | Lanius ludovicianus | 3 | | 3 | 1 | | 1 |
| Western meadowlark | Sturnella neglecta | 17 | 32 | 49 | | | |
| Vesper sparrow | Pooecetes gramineus | 9 | 21 | 30 | 16 | 6 | 22 |
| Desert sparrow | Amphispiza bilineata | 4 | | 4 | | 4 | 4 |
| Sage sparrow | Amphispiza nevadensis | | | | | 3 | 3 |
| Brewer's sparrow | Spizella breweri | 1 | | 1 | | 3 | 3 |
| Total individuals | | 82 | 104 | 186 | 53 | 39 | 92 |
| Total species | | 11 | 10 | 14 | 8 | 8 | 12 |

Each of the four plots was in proximity to juniper-pinon woodland or rocky areas, which partially accounts for the presence of such species as Cassin's kingbird, Say's phoebe, rock wren, and mockingbird.

A census at the close of the summer growing season, in late August or early September, would no doubt reveal an even greater difference in the comparative numbers of birds inside and outside of the Demonstration Area. Food and cover conditions inside the Area would then be better than in July, while outside the Area, because of heavy grazing, they would not materially change.

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# METHODS FOR ESTIMATING POPULATIONS OF MAMMALS[1]

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Technics for estimating the size of mammalian populations have been greatly improved in recent years, but these technics are still very imperfect and very little standardized. The meagreness of our knowledge about mammalian populations is due almost entirely to the difficulty of obtaining accurate counts of the number of individual mammals on the plots selected as samples and not to lack of statistical methods adequate for treating the data.

Most of the estimates of mammalian population density that have been made in the past are lacking in dependability. The so-called "censuses" of game populations published from time to time by various federal and state bureaus are, as a rule, only rough guesses. It is obvious that no game manager can cover a number of square miles of territory and know with any accuracy the number of elk, deer, bears, wolves, coyotes, bobcats, cougars, and other animals that live there. It is true that from the evidence of tracks and other signs he may get a general impression of mammalian abundance and he may even from time to time observe one or more of these animals. But naturalists will agree that any population figures he may produce are only crude estimates whose value is directly dependent upon the experience and judgment of the field man. With the enormous areas to be covered and the few experienced men available for the work it is unreasonable to expect accuracy in such estimates of game populations.

A complete count of the number of individual mammals living on a given area, no matter how small, is usually impracticable. Most wild mammals are shy and are adept at keeping out of sight. A majority of them also are nocturnal and many of the smaller forms spend the daylight hours hidden in burrows. Furthermore, the habits of the various kinds of mammals differ so greatly that often a special technic must be used to determine the population density of each species.

Counts of fair accuracy can, however, be made of the individuals of certain species. Thus, actual counts of fur seals on their breeding grounds can be made of the breeding males, breeding females, and pups of the year. But the numbers of non-breeding bachelor males, of young males, and of young females cannot be directly counted and must accordingly be estimated (Clark, 1916).

Some kinds of diurnal mammals may be counted by following the several individuals or groups about over their home ranges until all the animals on a given area have been identified. Carpenter (1934: 56–57) thus enumerated the number of howler monkeys living in groups on Barro Colorado island. He was not able to count the individuals

[1] Presented before a joint symposium of the Biometrics Section of the Statistical Association of America and the Ecological Society of America, under the chairmanship of V. E. Shelford, at Chicago, Illinois, December 26, 1940.

that were not living in groups and he could not obtain an exact tally of those in the groups. This method cannot be applied to species that are nocturnal nor to those that are very shy.

Counts from airplanes have been made of deer (Bennett, English, and McCain, 1940: 399), but it is doubtful, that an accurate enumeration can be made of such forest-inhabiting species when leaves are on the trees. Counting must be very difficult even under the most favorable conditions in winter after the deciduous trees have shed their leaves.

Counts of deer may also be made on limited areas by means of organized drives (Hosley and others, 1936; Adams 1938). In conducting such drives it is difficult, however, to make sure that all the regular inhabitants of the area are seen, for some deer are so shy that they may leave the plot immediately at the first disturbance before the counting lines are established. Again I have known deer to skulk in thick cover and remain undetected by the line of beaters. According to McCain (1939), the size of area needed for an adequate deer census has not yet been determined and under any circumstances a deer drive is expensive because of the labor involved. Nevertheless, when properly conducted over a sufficiently large area, a drive should give, for certain species of mammals, a reasonably accurate count of the population.

For making a count of the number of small mammals on a given plot, it is possible to trap practically all of the individuals present. The trapped animals may either be removed from the area (Bole, 1939: 25–26; Cahalane, 1941: 44–64) or marked and released where they are caught (Blair, 1940d: 274–275). To kill or remove individuals from an area will of course usually prevent further studies at that situation for a time and, therefore, the method of marking and releasing the animals alive is usually the better.

It must be admitted, however, that no trapping methods are ever completely successful and that the number of animals taken on a plot in one day seldom represents the whole population. Some individuals are almost certain to escape capture for at least a time. This difficulty can be in part overcome by using a large number of traps, but this is expensive in equipment and labor. If the traps are left set for a number of nights it is true that a larger proportion of the population will be caught but then immigrants and transients from outside the area also will be captured, giving an exaggerated indication of the size of the population. The setting of additional traps in a guard or buffer strip around the trap quadrat (Cahalane, 1941: 49) will not certainly prevent immigration onto the plot and these additional traps introduce other complications into the calculations (Dice, 1938: 126). The amount of immigration into a plot may be expected to be greater if the inhabitants are removed than if they are only marked and released.

The greatest difficulty in counting the small mammals on a given plot by trapping methods arises from the fact that each individual has a more or less definite home range which it may cover completely only at considerable intervals of time. Traps set on a given plot of ground tend, therefore, to catch not only the individuals that have their

home ranges confined within the limits of the trap plot, but also those having an overlapping range, although it is mostly outside the plot (Dice, 1938: 123).

The distance outside of the trap plot from which animals come to the traps will on the average be one-half of the average width of a home range for the sex and age class of the species concerned (Dice, 1938: 124). The writer would emphasize however, that the half of the width of a home range that must be added beyond the outside line of traps when calculating the effective area of the trap plot is an average figure only and does not apply properly to any isolated plot unless this is large enough to contain a very large number of individual home ranges.

The size of home range for any given species is best determined by the trapping methods developed with much success by Strunk (1931), Allen (1939), Burt (1940), Blair (1940a–d), Haugen (ms), and others. Traps are set in a regular pattern over the plot to be studied, the animals taken are marked and released, and the operations are continued until the home range of every resident individual of the species under study is known. On a chart that gives the location of each trap, those in which each individual animal was caught during a given season are indicated. It is a simple matter then to outline the home ranges.

The home range of the individual of course extends beyond the area indicated by the traps in which it was at various times caught. On the average, if the traps are set fairly close together, the influence of each trap may be assumed to extend for half the distance to the next adjacent trap. Therefore each individual home range must be extended for a distance of one-half the distance between traps on all sides of the traps in which it was caught. The distance between traps being known, the size of each home range can be calculated. It is of course recognized that the assumption that the home range extends half the distance to the adjacent traps is not justified when applied to any single home range, but is applicable only when used in combination with other ranges to calculate an average size of home range for the species.

The areas covered by each of a series of individual home ranges having been determined by this method, the mean area of home range for each sex and age class of the species may be calculated. The average width of a home range is then the square root of the average area. The standard error of the mean area of a home range can be ascertained by ordinary statistical methods (see Blair, 1940d).

Separate calculations must be made of the size of home ranges occupied by males and by females, by juveniles and by adults. Furthermore, the size of home range often varies with the season and perhaps also with the available food supply and with the density of population. The method is laborious and it has been used to determine the size of home range of very few species.

If each individual mammal of a given species and sex occupies a territory from which other individuals of the same kind are excluded, and if none of the space in a trap plot is unoccupied, then it should be possible to calculate the average width of the home range from the trapping records alone (Dice,

1938). Unfortunately, these conditions seem never to be fully realized. Within most plots some areas seem not to be included in any home range. The home ranges of the males furthermore, often overlap each other (Dalke and Sime, 1938: 667–668; Blair, 1940d, fig. 1). It is true that the breeding females of some species seem to occupy nearly exclusive territories (Burt, 1940: 26–29; Haugen, ms.) but in others the home ranges of the breeding females overlap broadly (Blair, 1940d, fig. 2). It is, therefore, almost never possible to calculate from a single set of trapping records the average width of home range and consequently the density of population for a given area.

The tracks of mammals may be followed in the snow and their home ranges and numbers thereby determined (MacLulich, 1937: 67; Stebler, 1939: 203–208). The method not only is laborious but requires the presence of newly fallen snow. Suitable tracking snow is only occasionally available even in those regions which remain snow-covered for a number of months in winter, and the method therefore is not widely applicable.

Another method of estimating mammalian populations makes use of the ratio between the numbers of marked and unmarked animals taken on an area where a known number of animals has previously been marked (Hosley and others, 1936). The most extensive use of this method for mammals has been by Green and Evans (1940: 220–238) who used it for calculating snowshoe hare populations. It employs a preliminary period during which as many animals as possible are caught in live traps, marked, and released. Some time later traps are again set and record made both of the number of the previously marked and of the unmarked animals captured. Then the ratio of the number of marked to previously unmarked animals captured in the second trapping period should be the same as the ratio between the number of animals marked in the first trapping period to the number that escaped marking at that time. The number of individuals marked in the first trapping period being known, it is easy to calculate the number of unmarked individuals present at that time and from that the total population. It is furthermore possible to calculate a standard error, based on the expected error of random sampling, and thus to have a measure of the statistical reliability of the results.

The validity of this method depends upon several assumptions that are not always satisfied in the field work. First it is assumed that there is a completely random distribution of the marked animals throughout the population. However, it is evident that animals which already have more or less fixed home ranges will not become distributed at random after they are marked. This objection may in part be met by widespread random trapping over the area both during the marking period and during the second counting period. Secondly, it is assumed that there is no loss of marked animals from the area between the first and second trapping periods, nor any increase of animals from any cause. If the area studied be completely enclosed it may be possible to make sure that there is no emigration or immigration, otherwise there will be some error in the calculations. Mortality is constantly occurring in wild

populations and will always introduce error. Increase in population due to reproduction will produce an error unless the counts be made at a season when no breeding is in progress. If the time between the first and second trapping periods be very short these sources of errors may be small, but they will never be wholly absent. Thirdly, it may be difficult to determine the limits of the area from which animals come to the traps unless the study is made on a completely enclosed plot. On open plots it must be assumed that the animals will be caught from an area extending one-half a home range beyond the settings of traps. This, of course, makes necessary a determination of the average width of home range for the species concerned. Furthermore, because the size of home range differs for males and females, for old and young, and at different seasons, it will be necessary to make proper allowances for these differences in the calculations. It seems likely, therefore, that the application of this proportional method of calculating mammalian populations may often require as much effort as the complete trapping or counting of the whole sample population.

Another proportional method has been suggested by Vorhies and Taylor (1933: 557–559), who counted the jack rabbits observed during a given period of time within a particular fenced enclosure and at the same time counted the number of cattle observed. It was assumed that the proportion of the number of cattle observed to those present in the enclosure would be the same as the proportion of the number of jack rabbits seen to the total number in the same area. The number of cattle actually present in the enclosure being known, the total number of jack rabbits was therefore calculated. However, the difference in habits and in visibility of cattle and jack rabbits is so great that it may be questioned if the ratios of numbers observed to those actually present can properly be assumed to be identical in the two species.

Formulas for calculating the number of rats in a population from the number of individuals taken in a given number of traps have been developed by Leslie and Davis (1939). These are based on the assumptions that the movements of rats are at random and that the trapping technics are so efficient that any rat coming into contact with a trap is caught. The law of movement of molecules in a gas should, with some modification, therefore apply. However, the slight information we have about the behavior of mammals in nature is that their movements are not at random. Neither are any trapping methods fully efficient. It is doubtful, therefore, if the assumptions of this method are sound.

The difficulty of obtaining accurate counts of the number of individual mammals present on a given area has led to attempts to develop indices of abundance for the species concerned. Such indices may or may not be convertible into terms of population density. For many practical uses however, it is sufficient to know the relative abundance of a particular species in different areas or at different times, without having an exact count of the population.

One of the earliest invented indices of abundance for mammals is that of the trap-night (Grinnell, 1914: 92). The number of individuals of the species concerned which are caught in a given

time is divided by the product of the number of traps set multiplied by the number of nights the traps are in service. If the traps are always set by a person with the same amount of experience the same distance apart, in the same general type of habitat, for the same number of days; and, furthermore, if the traps are all of the same type and are in equally good condition, if the same kind of bait is always used, and if the weather conditions are the same during all the trapping operations, then the figures obtained are reasonably comparable, but otherwise they are not. The chief difficulty with the use of the trap-night as an index of abundance is that it ignores the fact that each animal is resident in a more or less fixed home range that covers a definite area. If ten traps are set close together, they may all fall within the home range of a single individual mammal, and when this individual is captured there may be no others to take its place. On the other hand, if the traps are set far apart, they may fall in ten different home ranges and take ten individual animals, or, if the home ranges of several individual mammals overlap, more than ten animals might be taken within a few days. It is obvious, therefore, that the length of the trap line is of more importance in getting an index of abundance than the number of traps or the number of days and nights these remain in operation (Dice, 1938: 128).

Useful indices of abundance may be obtained from the signs of the presence of a given species on sample plots selected at random. The fecal pellets are particularly useful evidence of the presence of certain species of mammals (Taylor 1930: 531–534; Elton, Davis, and Findlay 1935: 280–281; Hamilton 1937: 783). Sometimes it is possible to count the number of pellets on each of a number of quadrats and thus obtain a still more accurate index of abundance (Vorhies and Taylor 1933: 559–563; MacLulich 1937: 36–39). By determining the average number of pellets produced in captivity per day by one individual of the species concerned one may calculate the actual population per unit area (Hendrickson 1939: 209–212). In such a calculation of population density it is, however, impossible to achieve very great precision, because of the difficulty: (1), Of determining the durability of the pellets in nature under varying weather conditions; (2), of allowing for the variation in the numbers of pellets produced by individuals of the several age classes and sexes when feeding on the same or on different foods; and (3), of procuring a sufficient number of random samples to overcome the statistical difficulty that the pellets are not distributed at random by the animals.

A more satisfactory index of abundance is given by counts of the number of homes of a particular species present on a given area (Taylor 1930: 528–529). Kangaroo rats make conspicuous mounds (Monson and Kessler 1940); tree squirrels often have leaf nests (Goodrum 1937; Baumgartner 1938); and beavers make conspicuous dams and houses (Atwater 1940). There is some difficulty in making sure that the home to be counted is in present use by an animal, for many of these structures persist for some time after the death or emigration of the builder. Also some individual animals may construct and occupy more than one home at the same time. Furthermore, a single home may

be occupied by more than one individual. It is obvious, however, that the presence of a large number of homes indicates a larger population than does that of only a few, though it is seldom possible to calculate the actual populations from this kind of data.

Counts of the mammal tracks that cross a trail or fire line can also be used to obtain an index of abundance. Ruhl (1932: 448) calculates an index of the abundance of deer and other animals by reducing the counts to the number of tracks made per hour across an average mile of line. A somewhat similar index for deer in their yards is procured by counting the number of beds per acre made immediately after a snowfall (Bartlett and Stephenson, 1929: 413).

An index of gray squirrel abundance based on the number of individuals seen during a given time has been used by Goodrum (1940: 10–11). The same author has used, but with less success, an index based on the number of squirrels treed per hour by a dog.

A simple frequency index may be derived by noting only the signs or actual presence of the species concerned on a series of quadrats selected at random. Thus, if signs of snowshoe hares are found on each of 10 out of 25 random quadrats the frequency index would be 40 per cent (see Dice 1931). The size of quadrat employed should preferably be larger or the quadrats should be spaced farther apart than the width of a single home range of the species. This method has been used with much success in studies of plant ecology but has so far been little used for mammals.

A dependable index to mammalian population density may usually be obtained from traps set according to a standard plan. Mammalogists usually set their traps in lines, because a line is more easily set and serviced than a grid. Traplines of measured lengths maintained for a standard number of days should secure samples of the populations that are comparable for different types of habitats, different seasons, or different areas.

The length of trapline necessary to capture a sufficient number of individuals to provide data for statistical comparisons depends upon the average width of the individual home ranges of the species concerned. In general the trap line must be long enough to capture a sufficient number of individual animals to give a reliable sample of the population. If we wish to capture a minimum of 10 animals then the trap line should extend at least long enough to include the home ranges of that many individuals.

One method commonly employed to obtain an index of mammalian abundance is often improperly used as a basis for calculating population density. The observer walks or drives in an automobile a measured distance through the area and counts the number of individuals that he sees of the species concerned. Then he assumes that all the individuals are observed to an average certain distance on each side of his path and from this he calculates the population per acre or per square mile. A variation of this method is to have several observers walk in a line.

Such counting should give a good index of relative abundance if due attention is paid to type of cover, season, weather, time of day, experience of the observer, and other factors that may affect the result. But to calculate from

such evidence the actual number of individuals per unit area gives a false semblance of precision. The distance from the observer at which animals flush is highly variable, as any hunter can testify (see Erickson, 1940). Also the distance at which animals are seen depends upon the thickness of the cover, on the activity of the animals, on the light conditions, and on numerous other factors, of which the alertness of the observer is not the least important. When, in a modification of the method, the attempt is made to count only the individuals seen within a certain specified distance of the path or the highway the possibility of error in estimating the correct distance likewise is very high. For these reasons it is highly unscientific to attempt to estimate the actual density of mammalian populations per unit area from such observations.

The indices of mammalian abundance described above are undoubtedly of value to the game manager who is interested in knowing whether a given species is increasing or decreasing in abundance at a given locality. There is considerable difficulty, however, in converting any of these indices into terms of actual populations. If mathematical formulas allowing for such conversion are later developed it is unlikely that they will be much used, because the number of observations necessary in order to provide a satisfactory statistical base will almost certainly be in excess of that which it is practicable to make.

Counts made on sample plots or lines will nearly always furnish the basic data on which estimates of mammalian populations are made and it is, therefore, important to be able to determine whether the plots or lines used are large, numerous, or typical enough to provide a reliable basis for the calculations. Statistical methods for testing the reliability of the means derived from the samples have in the past been little used by mammalogists. We can be sure, however, that statistical analysis will become increasingly important in the future as biological technics for obtaining population counts in the field become improved. When comparable counts are available in quantity, their interpretation and evaluation will require many new applications of statistics.

## SUMMARY

Counts of the number of wild mammals in a population are usually difficult or impossible to make because the animals are highly mobile, most of them are shy, and many are nocturnal in habit. The estimates of mammalian populations that have been made up to the present time are mostly based on inadequate data and accordingly very few of them are at all accurate. Most of the field methods in use need further refinement and standardization before they will yield satisfactory data in adequate quantity for statistical treatment. For a few kinds of mammals there have been developed indices of abundance that are easier to obtain than are complete censuses, but which for certain practical purposes are nearly as useful.

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# DISTRIBUTION OF COTTONTAIL RABBITS IN WASHINGTON STATE

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The Provisional List of the Land Mammals of the State of Washington (Taylor and Shaw, 1929) gives a rough outline of the range of the native cottontail rabbit. During the past several years a number of records have been obtained that make it possible to show the distribution of this mammal in the State with considerable accuracy. Since the list was published at least four successful plantings of cottontail rabbits from the eastern part of the United States also have been made. In view of these facts it is thought advisable to review the status of the genus *Sylvilagus* in Washington.[1]

## Discussion by Species

*Sylvilagus n. nuttallii.*—This rabbit is found among the rocky coulees and brushy areas of the eastern part of the State. On the south it ranges from the Idaho border west to several miles west of Grand Dalles, in the Columbia River Valley. It is absent from the Blue Mountains but crosses the eastern part of the Simcoe Range and extends north in the Yakima Valley to the Wenatchee Range. It occurs again north of the Wenatchee Range and ranges as far north as British Columbia (Cowan, 1940) in the Okanogan River Valley and westward in the Methow Valley. It occurs east of the Okanogan River, in the Okanogan Valley and also on the rocky plateau to the south and west of Omak Lake. It is also found in a narrow area along the north bank of the Columbia River, on the southern edges of Okanogan and Ferry counties, extending northward in the valley to Kettle Falls and Colville. (Fig. 1.)

Fig. 1. Distribution of *Sylvilagus* n. *nuttallii* in Washington.

*Sylvilagus floridanus mearnsi.*—A single introduction of non-native cottontails in eastern Washington is known to the writer. This occurred near Pullman, Whitman County. Dr. George E. Hudson, of the Charles R. Connor Museum, Washington State College, has investigated this planting and has furnished a copy of a letter about it written to him by Will R. Heglar, May 15, 1939. Mr. Heglar was chairman of the Whitman County Game Commission when eastern cottontails were introduced. The following is from his letter:

"In the years of 1926–1927 the Whit-

[1] The writer is indebted to Dr. George E. Hudson of Washington State College, John Biggs and Burton Lauckhart of the Washington State Department of Game, Theo. H. Scheffer and Dr. Victor B. Scheffer of the United States Fish and Wildlife Service, and to John Slipp of the University of Washington Department of Botany, for information about cottontail plantings in the State.

man County Game Commission introduced into Whitman County 12 pair of eastern cottontail rabbits and released six pair on Dry Creek, about four miles north of Colfax, Washington, and released 6 pair in the vicinity of Pullman. I do not know the exact location but believe it was near the present site of the grounds of the Pullman Gun Club. These rabbits were shipped from Kansas, but I do not remember the shipping point. I have searched the old records for information but have been so far unable to find anything giving the information."

According to Nelson (1909) three races of cottontails occur in Kansas, namely *Sylvilagus floridanus mearnsi*, *S. f. alacer*, and *S. f. similis*. On September 24, 1940, Dr. Hudson wrote the author that he had sent five skins of the eastern cottontail from Pullman to the California Museum of Vertebrate Zoology. These were identified by Dr. Seth B. Benson as "*floridanus*, probably the sub-species *alacer* or *mearnsi*." In an earlier letter (February 5, 1940) Dr. Hudson wrote, "I sent two of these rabbits to Washington [D. C.], and they were identified as *mearnsi*."

*Sylvilagus floridanus alacer*.—Another introduction of cottontails was made in Clark County. John Biggs, State Game Protector at Vancouver, Washington, has investigated this planting and kindly supplied the following facts (September 12, 1940):

"These rabbits were released in November, 1933, by Dr. J. G. Beattie of Portland, Oregon. Dr. Beattie at that time owned the Daybreak farm near Battleground, Washington, and released the rabbits to use in training a pack of beagle hounds which he had. The rabbits, two dozen in number, were purchased from a Mr. Ferril, a rabbit dealer in Neosho, Missouri. They were not pairs but were 'trap run.' Of the two dozen rabbits, Dr. Beattie says a least 12 were caught and killed by the dogs before they had a chance to reproduce."

"In the fall of 1935 cottontail rabbits were common in the Daybreak district. Since that time they have spread in a radius of at least fifteen miles, and in some places greater distances, from the point of release. They are now common in almost the entire western half of the county. For a while this spring, heavy hunting seemed to have reduced them a lot, but at the present time they seem as thick as ever. I would estimate their numbers in this county at this time at a minimum of 40,000, and this figure could easily be much larger."

The only cottontail in Missouri according to Nelson (1909) is the subspecies *alacer*.

*Sylvilagus floridanus* subspecies?—Eastern cottontails were released near the Auburn Game Farm, King County, in 1927. John Slipp of the University of Washington Department of Botany called this introduction to the writer's attention. Mr. Slipp made several trips to the region where the rabbits were released, collected specimens, and interviewed people connected with the introduction. The following information is from his notes.

Charles D. White, then manager of the King County Game Farm, obtained two dozen cottontails from Kansas (exact locality unknown) in 1927. Apparently it was originally intended to raise the rabbits at the game farm but they became very sick from eating cabbage

and thirteen of the two dozen died. The remaining eleven were released to fare as best they might. By the summer of 1928 they were abundant, and White reported them as far east as Enumclaw. Mr. Slipp found them north almost to Kent and south to Sumner. They are reported to occur at Berrydale, near Black Diamond, Cow Lake, and Lake Tapps.

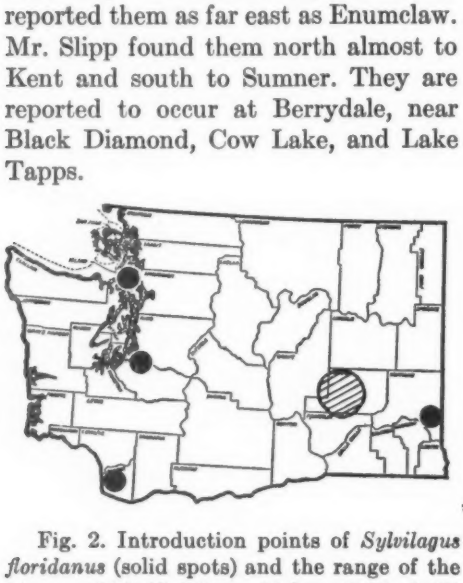

Fig. 2. Introduction points of *Sylvilagus floridanus* (solid spots) and the range of the pigmy rabbit (*Sylvilagus idahoensis* (shaded)) in Washington.

Eastern cottontails were introduced on Whidbey Island in Puget Sound and have become very abundant there despite constant hunting. Theo H. Scheffer has a letter about them from L. N. Freimann, Island County Agent, who writes as follows (January, 1939): "The cottontail rabbits which were introduced from Kansas in 1931 have increased very rapidly. Unfortunately someone has introduced the same stock on the north end of Whidbey Island, and we have noted that they are also increasing at an alarmingly fast rate."

In the absence of typical series of *alacer, mearnsi,* and *similis* for comparison, it is not possible to refer the Whidbey Island or the Auburn rabbits to any one subspecies. The writer's specimens from Whidbey Island seem to differ somewhat from the rabbits collected by Slipp at Auburn. It is possible that all three of the races mentioned have been introduced in Washington. Localities in which these rabbits have been stocked are indicated in Figure 2.

*Sylvilagus idahoensis.*—This rabbit was recorded by Taylor and Shaw (1929) from Warden, Grant County; Ritzville and Lind, Adams County; and central Adams County. There appear to be no new record stations. (Fig. 2)

## REMARKS ON THE INTRODUCTIONS OF RABBITS

In the thirteen years that have elapsed since eastern cottontails were released near Pullman, the rabbits have increased and spread considerably. Dr. Hudson writes (September 24, 1940) that:

"Mr. Norman Knott, biologist for the State Game Department, worked on cottontails around Pullman several years ago. He tells me that out of 88 cottontails he handled, 5 were the native *nuttallii* and 83 were the introduced *floridanus*. My own observations of rabbits killed in this vicinity indicate that practically all of the cottontails that occur near Pullman are the eastern form."

It is interesting to note that the eastern cottontails near Pullman have not increased so rapidly nor spread so far as have the cottontails introduced in western Washington. This may be due to the more arid climate, colder winters, competition with the native species, or all of these factors, combined. Whether the introduced form will displace the native rabbit over any great proportion

of the sagebrush region remains to be seen.

There are no native cottontails in western Washington, nor is there any evidence that cottontails have occurred naturally in western Washington in post-Pleistocene times. A cottontail (*Sylvilagus bachmani ubericolor*) lives in western Oregon, but seems never to have crossed the Columbia River.

The cottontails introduced at Auburn (1927) were the first to be released in western Washington. The boundaries of this colony are imperfectly known but seem to extend twenty miles east of the point of release, and at least ten miles north and south.

The introduced cottontails on Whidbey Island now occupy the entire island but have not become established on the nearby mainland. The north end of Whidbey Island is now accessible by a bridge which conceivably the rabbits may cross. They may also be brought to the mainland by man, accidentally or as pets.

Residents of Whidbey Island told the writer that before the cottontails were introduced on the island, the Washington snowshoe hare (*Lepus americanus washingtoni*) was found there, but it disappeared after the cottontails became common.

The Clark County introduction is probably the most important of the plantings in the State. In the seven years since the rabbits were introduced, they have scattered widely and there are no apparent barriers to their further spread.

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# NOTES ON THE CRUISING METHOD OF CENSUSING WHITE-TAILED DEER IN OKLAHOMA[1]

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In the early part of February, 1940, the writers were confronted with the problem of how to census the white-tailed deer (*Odocoileus virginianus louisianae*) in southeastern Oklahoma. Several methods were considered, including the widely used deer drive, the track count, and the rather recently developed cruising plan. The pellet count of Bennett, English, and McCain (1940) could not be considered because it was then unknown to us. Use of the deer drive, dependent on the availability of large numbers of men, was impracticable. There was doubt, furthermore, that this method could be used with sufficient accuracy because the deer population was low and in extremely rough terrain. Track counts showed even less promise due to dearth of snow. The cruising system, first developed by Erickson (1940) in censusing white-tailed deer in the spring and summer in St. Croix State Park, Minnesota, showed the greatest adaptability, and was used. Certain techniques were devised which the writers believe have increased the accuracy of the method.

Without doubt the deer range studied is the most mountainous section of the State. It occupies approximately 3,500 square miles with two principal east-west ranges, in addition to a large number of smaller mountains. Rich Mountain, with an elevation of 2,850 feet above sea level at the Arkansas State Line, has been reported to be the highest. The most important and extensive type of vegetation is the rather open oak-pine forest which consists largely of shortleaf pine (*Pinus echinata*) and a mixture of black hickory (*Carya buckleyi*) and such oaks as white oak (*Quercus alba*), blackjack oak (*Quercus marilandica*), and post oak (*Quercus stellata*). The two most common kinds of vegetation in the understory are huckleberries (*Vaccinium* spp.) and blue-stem grasses (*Andropogon* spp). Practically all of this oak-pine forest has been logged sometime in the past, or is being cut at the present time. Overgrazing by livestock is prevalent and much of the deer range is burned every winter and spring. The vegetation adjacent to the streams and other mesic sites has a larger number of plant species, but the area in this type is so small as scarcely to influence the results of the deer census.

Before censusing, representative areas for the work were selected over the entire deer range. Aerial photographs, county road maps, and a wildlife food and cover type map of the region were consulted in determining locations and sizes of the sample areas. The principal factors affecting choice of sites were percentage of cultivated land, proximity of centers of human population, number and class of roads, topography, and hunting pressure during the previous

[1] This study was carried out under the supervision of Lyle F. Selko, Director, Division of Federal Aid, Oklahoma Game and Fish Department, as part of the "Statewide Wildlife Survey, Restoration and Management Project" also known as Pittman-Robertson Project No. 2-R.

open season. Determination of the size of the areas was governed largely by these same factors, combined with those of mobility of the deer and the amount of time that could be allotted to each place. Trials showed that areas two square miles in size were too small, but proved that those of four square miles were satisfactory.

In applying the cruising method to each sample area, both of the writers followed census lines, using box compasses to determine directions, and pacing to measure distances traversed. Carrying a pedometer for recording the distance covered by pacing was particularly helpful since it gave the census taker more time and opportunity for making observations. The lines were run in cardinal directions over each sample area at half mile intervals so that half of the boundaries were covered. During February and March of 1940, sixteen miles of census lines were run on each sample by both census takers, making a total of 240 miles on fifteen areas. The findings on these samples, together with the results obtained from deer drives made on two additional areas in recent years were used as a basis for estimating total deer populations.

Erickson, in writing of the use of the cruising method in Minnesota, listed the following factors that should be especially kept in mind: "the distance between cruising lines, density of cover, running distance, flushing distance, sight distance, cover visibility, type of cover, and sex and age of the deer." These were also found to be important in Oklahoma, as were two other considerations, namely, choice of proper weather conditions for the census and technique for covering the census lines. Cloudiness, temperature, rainfall, and wind velocity and direction all influenced the results, but some were more dominant than others. Although it was impossible to conduct all of the censuses on days which might be classed as ideal, it was possible to choose days when weather conditions were largely favorable. The day considered best was cloudy, with very little wind, when the ground was fairly moist from rainfall the night before. Weather conditions affecting the work varied also with the time of day and the season of the year; wind velocity and direction were most important. Early morning and late afternoon hours were best because the wind was less strong and the chances of seeing deer were greater. As a rule we began shortly after sunrise in order to allow plenty of time to cover the census lines before noon. When adverse weather conditions prevailed during a particular morning or afternoon, no censusing was done.

As to technique for covering the census lines, it was found that the best practice was to proceed in "hunting fashion"—in other words, to stalk the deer along the census route just as a hunter might do. Plenty of time was taken, and only approximate compass sites were used to determine the route of travel. It was found particularly important that the census taker often stop to look around and thus avoid walking past some of the deer. Time was taken to sit on a stump, log, or rock, to lean against a tree, or to stand perfectly still for a short while, to make observations. Complete notes were taken on all deer flushed and on deer signs, as tracks, pellets, and evidences of

browsing. Flushing distance, i.e., the distance from the census taker to the point where the deer started to run, was obtained by pacing. Cover visibility, or the distance from the observer to the point where the deer disappeared from view, was determined in like manner. Note was also made of the time of observation, the direction each deer ran, the approximate size of each animal, and any other data that might aid in avoiding duplications. At the time of year (February) it was not possible to determine sex accurately because the bucks had shed their antlers. Immediately following completion of the work on each area the census takers compared observations. Whenever there appeared a chance that a certain deer had been counted twice, one of the investigators eliminated a tally from his notes. The population on each area was then computed by the use of King's ruffed grouse formula as explained by Erickson.

Following completion of the census work on all of the sample areas it was apparent that some of the modifying factors listed by Erickson exerted a greater influence under Oklahoma conditions than they did in Minnesota. Because of the open nature of the oak-pine forest, density of cover was not so important as the average flushing distance was 246 feet compared to 140 feet in the aspen type in Minnesota; also cover visibility was only 100 feet in that type compared to 366 feet for the Oklahoma oak-pine forest. Sight distance was greater at all times, largely because of the more open forest. Running distance was found to be about a quarter of a mile and was the same in both states; this was the principal reason that the census lines were run at half-mile intervals.

Encouraging results were obtained as 45 deer were flushed by the census takers. It was particularly gratifying that so large a number were observed, since the average deer population per square mile in Oklahoma is only about a tenth that in Minnesota. In areas known to support higher populations, the number of deer flushed and amount of deer sign observed were greater in proportion. As a check, a census was made in the center of the McCurtain County State Game Preserve where a high population was known to be present and 21 deer were observed. On a census area six miles from the preserve, which was known to support a much lower population, only three deer were flushed. On a few of the sample areas no deer were observed and the amount of deer sign was scanty. The population of such areas was calculated on the amount of sign found in relation to that on the nearest comparable area where deer were observed.

The censusing, in addition to giving deer population figures provided opportunity to learn about deer movements, to observe utilization of browse and mast, to study limiting factors, and to get population estimates for other species, such as the bob-white (*Colinus v. virginianus*) and the cottontail (*Sylvilagus floridanus alacer*).

In conclusion the authors wish to emphasize that the cruising method of censusing white-tailed deer has yielded excellent results in southeastern Oklahoma. It is a particularly economical method, hence practical for determining populations as a basis for hunting regu-

lations. However, the size of the fawn crop must be determined to obtain fall population estimates. Even though care is used in choosing proper weather conditions, and in employing the technique advocated in this paper as aids to obtaining accurate results, the findings presented are by no means regarded as final. Erickson expressed the hope that other investigators would experiment with the cruising method and improve upon its technique. The authors believe that they have improved upon the method for use under Oklahoma conditions, and feel that their estimate of 3,125 white-tailed deer on 3,500 square miles of range in southeastern Oklahoma in March, 1940 was very close to the actual population.

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# OBSERVATIONS ON THE RELATIVE IMPORTANCE OF WINTER DEER BROWSE SPECIES IN CENTRAL NEW YORK[1]

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Incidental to field work on other subjects, data were gathered regarding the plants cropped and the extent to which they were browsed by white-tailed deer on the Connecticut Hill State Game Refuge near Ithaca, New York, during the winters of 1938–39 and 1939–40. Notes were taken on 2,089 individual browsings by deer, involving 42 species of woody plants.

## The Study Area

The Connecticut Hill area, on which this study was conducted, is located about 12 miles southwest of Ithaca among the high hills characteristic of that region. Although the crest of Connecticut Hill is approximately 2,000 feet in elevation, most of the area studied lay between the 700-foot and 1,700-foot contours in typical Transition Zone beech-birch-maple-hemlock forests.

The area involved about 1,000 acres on eight different sections scattered at random over the 4,300-acre refuge. The entire reservation is made up of abandoned farm lands that have largely reverted to forest. It includes more than 700 acres of open fields and 300 acres of dense pine plantations. The naturally wooded areas consist of about 1,000 acres of poplar and sumac brushland, in an early stage of succession, and about 2,000 acres of uneven-aged sub-climax and climax forests. In addition, experimentally-cleared slash areas, comprising some 300 acres, contain dense growths of young maple and birch, and of blackberry, raspberry, and witch-hazel plants.

The deer range is of especial interest in that, at the present time, it is not over-browsed. Many of the Pennsylvania forests, not far to the southward, give indications of over-stocking, but on the present area, deer, although common, have not become over-abundant. This is evidenced by the absence of starving deer, the lack of a browsing line in the forest, the failure of the deer to consume pine and other low-quality browse, and the abundance of seedlings of all species (except American yew) upon the forest floor. Hence it is believed that the data here presented are representative of the winter browsing of a normal deer population in the forests of central New York.

## Methods

Notes regarding the plants cropped, their abundance, and the frequency with which they were browsed, were recorded in the field along the routes followed while working with a crew conducting a strip census of ruffed grouse. The censuses were made weekly on representative sections throughout the refuge and records of deer-browsed twigs were taken at random along the strips traversed. Notes for both years were collected principally in late spring

[1] A contribution from the Department of Zoology, Cornell University, Ithaca, New York.

so as to include browsing of the previous winter. The periods of study extended through April and May, in 1939, and from December, 1939 through May, 1940.

## WINTERING HABITS OF DEER ON THE STUDY AREA

The form studied in this investigation was the northern white-tailed deer (*Odocoileus virginianus borealis*). Under normal winter conditions, this race does not yard in the Ithaca region, but feeds generally over both forests and open lands. Although temperatures often hover near the zero mark and snowfalls are common, above-freezing temperatures are usually sufficiently frequent to prevent the accumulation of snow to a great depth upon the forest floor. Excepting for periods of short duration, snow depths of 1 to 1½ feet, aside from drifts, are maximum. During the winter of 1939–40, however, abnormally great snowfalls and persistently low temperatures caused approximately three feet of snow to remain in the forests from the middle of February until the first of April. During this period the deer were concentrated on southern and eastern slopes and were forced to browse severely all plant species regardless of food preferences. Records of these more abnormal browsings, therefore, are not included in the data here presented.

## FEEDING HABITS

During both of the winters of study, deer were able to obtain herbaceous plants, low shrubs, fallen fruits, and other food from the surface of the ground until late December. Until that time but few and scattered browsed twigs could be found in the forests. It was not until mid-January, in 1940, that extensive browsing commenced. From early January until late April, during both years, however, snow persisting under the forest canopy, forced the deer to subsist primarily upon the available browse. It was quite evident, too, that browsing was not confined entirely to the winter period, for low shrubs, such as American yew (*Taxus canadensis*), and the seedlings of taller species, were often thoroughly eaten back although they were covered by snow during the winter.

Normally, the twigs of the previous year's growth were chosen for food and in only a few cases was older wood consumed. The more succulent plants were usually browsed much more thoroughly than were those of a less watery nature. One twig of basswood (*Tilia americana*) was found to be browsed back so far that the remaining stub measured $\frac{3}{8}$ inch in diameter. In contrast, browsed twigs of hemlock (*Tsuga canadensis*) were rarely eaten back to a size larger than $\frac{1}{16}$ inch. This preference likewise operated so that sucker shoots were invariably taken. Experimental slash lanes through the forest were much visited as a source of succulent materials. Frequently every twig of small, vigorous seedlings was browsed back. This damage was not then, at least, of serious consequence on the study area.

## CLASSIFICATION OF WINTER BROWSE SPECIES

Professor Aldo Leopold (1933: 259) classifies the dietary items of game animals as; preferred, staple, emergency, stuffing, and pastime foods. For the deer under consideration, the available

browse species fall into these several classes as shown in Table 1. The species within these groups are listed according to the descending order of their apparent palatability.

Preferred foods have been defined (Leopold, 1933: 259) as "the foods eaten and seemingly preferred for as long as they last during the winter—after the foods characteristic of summer have disappeared." This is in contrast to staple foods which form "the foundation of winter sustenance" and are "resorted to after the supply of preferred foods has dwindled." Slight modification of these concepts was necessary in application to the present study for although some plant species, such as sumac, occurred in dense stands, others as the dogwoods were scattered through the forests. While plants of the former type were often consumed in quantity at an early date, some of the latter group remained untouched until they were discovered by wandering deer in late winter. When found, however, they were greedily consumed. In this analysis, species that were noted to be consistently and severely browsed were considered to be preferred, while species usually of greater abundance, that were rarely heavily cropped but nevertheless, formed the bulk of the browse taken, were regarded as staples.

Some difficulty was experienced in assigning browse species to the other groups. Not only did some plants obviously possess intermediate qualifications, but conditions causing the utilization of emergency foods did not occur except in areas of temporary deer concentrations and in those areas staple food plants predominated. Although appraised somewhat by comparisons with browsed pine and hemlock in areas of concentration, species assigned to the emergency food category were so placed because, despite their abundance, they were but slightly browsed. Doubtless, however, these are the species that would be utilized in the event of a shortage of staple foods. They are important as reserve supplies.

It may be considered surprising that hemlock is placed under the "emergency" category. Although this species is important in the diet of deer over most of New York State (Gardiner Bump, personal communication), its utilization on the Connecticut Hill area

TABLE 1

CLASSIFICATION OF PRINCIPAL WINTER DEER FOOD PLANTS IN THE ITHACA, N.Y., REGION

| *Preferred*[1] | *Staple* | *Emergency* | *Stuffing* | *Pastime* |
|---|---|---|---|---|
| Round-leaved dogwood | Red maple | Hemlock | Blueberry | Hemlock? |
| Staghorn sumac | Sugar maple | White pine | Bush honeysuckle | Blackberry? |
| Flowering dogwood | Striped maple | Red pine | Sweet fern? | Blueberry? |
| Basswood | Witch-hazel | Scotch pine | Meadow sweet? | |
| Apple | Birch | Beech | | |
| Hobblebush | Oak | Juneberry | | |
| | Large-toothed aspen | Blue beech | | |
| | Trembling aspen | White ash | | |
| | Maple-leaved viburnum | Willow | | |
| | | Blackberry | | |

[1] American yew, evidently a preferred species, had been so severely browsed, on the study area, that it was covered by snows and thus rendered unavailable during winter.

was surprisingly slight. Despite the great abundance of hemlock and a careful survey by the author checking its utilization, no evidence was found during either season that would justify its being considered a staple food of the deer on the study area. As with the other species of emergency value, the the author believes that hemlock would be consumed extensively here only upon the depletion of more favored browse. Its abundance would then make it of great importance.

Classing species as stuffing foods was of doubtful accuracy, being based upon their moderate abundance in the limited areas where they grew and their apparent lack of nutritional value. If all browse of a more desirable nature became depleted, these species would probably be eaten. Possibly some of the species low on the list of emergency foods should be transferred to this category. Pastime foods, according to Professor Leopold, are not consumed because of hunger, but rather for relief of nervousness or just to pass the time. Occasional twigs of the species assigned to this class seemed to have been taken with no serious intent to satisfy hunger despite the abundance of these possible emergency foods. Extensive data for this class of food are, however, lacking in this investigation.

Preferred foods comprised 21.8%, staples 61.1%, emergency foods 14.5%, and miscellaneous species 2.6% of the total number of browsings recorded.

## THE RELATIVE IMPORTANCE OF WINTER DEER BROWSE SPECIES

The degree of utilization of certain browse species has been discussed or implied in the preceding classification of species according to their palatability, but the actual importance of such species on the deer range is greatly affected by their abundance. The relative importance of all available browse species is here estimated according to their utilization as modified by their availability. Flowering dogwood (*Cornus florida*), for example, although a preferred food species, was limited in total value by its rarity. On the other hand, staghorn sumac (*Rhus typhina*), although likewise a preferred species, was comparatively abundant so that its importance was great. Similarly, birch (*Betula*), oak (*Quercus*), and round-leaved dogwood (*Cornus rugosa*) were all found to be of "medium" importance, despite the fact that the first two forms were staple foods while the last was preferred. The abundant, but less palatable, birch and oak appeared to be equal in value, as judged by utilization, to the more tasty but uncommon dogwood.

Of the 42 plant species noted available as deer browse (Table 2), six were never recorded as eaten. Four of the remaining 36 browsed species were considered to be of great value. These were the red maple (*Acer rubrum*), sugar maple (*Acer saccharum*), staghorn sumac (*Rhus typhina*), and witch-hazel (*Hamamelis virginiana*). Of "medium" importance were large-toothed aspen (*Populus grandidentata*), quaking aspen (*Populus tremuloides*), birch (*Betula*), oak (*Quercus*), striped maple (*Acer pennsylvanicum*), and round-leaved dogwood (*Cornus rugosa*). The eleven species of "fair" quality were, collectively, quite important in that they comprised a moderately large percentage of the total browse recorded, while 21 species, including the six unbrowsed forms, were

TABLE 2

WINTER BROWSE SPECIES UTILIZED BY DEER IN THE ITHACA, N.Y., REGION

| *Scientific name* | *Common name* | *Browsings noted* | *Abundance* | *Utilization* | *Relative importance*[1] |
|---|---|---|---|---|---|
| Acer pennsylvanicum | Striped maple | 55 | Common | Medium | Medium |
| Acer rubrum | Red maple | 352 | Abundant | Great | Great |
| Acer saccharum | Sugar maple | 275 | Abundant | Great | Great |
| Amelanchier | June berry | 35 | Common | Slight | Slight |
| Betula[2] | Birch | 121 | Common | Great | Medium |
| Carpinus caroliniana | Blue beech | 32 | Common | Fair | Fair |
| Castanea dentata | Chestnut | 5 | Rare | Medium | Slight |
| Cornus florida | Flowering dogwood | 18 | Rare | Great | Fair |
| Cornus rugosa | Round-leaved dogwood | 86 | Uncommon | Great | Medium |
| Corylus americana | American hazel | 4 | Uncommon | Slight | Slight |
| Corylus cornuta | Beaked hazel | 10 | Uncommon | Slight | Slight |
| Crataegus | Hawthorn | 1 | Uncommon | Slight | Slight |
| Diervilla lonicera | Bush honeysuckle | 3 | Common | Slight | Slight |
| Fagus grandifolia | Beech | 64 | Abundant | Slight | Slight |
| Fraxinus americana | White ash | 33 | Common | Fair | Fair |
| Fraxinus nigra | Black ash | 1 | Rare | Fair | Slight |
| Hamamelis virginiana | Witch hazel | 176 | Abundant | Medium | Great |
| Magnolia acuminata | Cucumber tree | 1 | Rare | Fair | Slight |
| Malus pumila | Apple | 32 | Uncommon | Great | Fair |
| Myrica asplenifolia | Sweet fern | 0 | Uncommon | Slight | Slight |
| Ostrya virginiana | Hop hornbeam | 0 | Uncommon | Slight | Slight |
| Pinus resinosa | Red pine | 0 | Common | Slight | Slight |
| Pinus strobus | White pine | 0 | Common | Slight | Slight |
| Pinus sylvestris | Scotch pine | 0 | Common | Slight | Slight |
| Populus grandidentata | Large-toothed aspen | 110 | Common | Medium | Medium |
| Populus tremuloides | Quaking aspen | 54 | Common | Medium | Medium |
| Prunus | Cherry | 4 | Uncommon | Medium | Fair |
| Quercus[3] | Oak | 107 | Abundant | Medium | Medium |
| Rhus glabra | Smooth sumac | 1 | Rare | Great | Slight |
| Rhus typhina | Staghorn sumac | 169 | Common | Great | Great |
| Rubus | Blackberry | 7 | Common | Slight | Slight |
| Salix | Willow | 69 | Common | Fair | Fair |
| Sassafras officinale | Sassafras | 6 | Rare | Medium | Slight |
| Spiraea latifolia | Meadow sweet | 0 | Uncommon | Slight | Slight |
| Tilia americana | Basswood | 38 | Uncommon | Great | Fair |
| Tsuga canadensis | Hemlock | 59 | Abundant | Slight | Slight |
| Ulmus americana | American elm | 4 | Uncommon | Slight | Slight |
| Vaccinium | Blueberry | 18 | Common | Slight | Slight |
| Viburnum acerifolium | Maple-leaved viburnum | 26 | Uncommon | Medium | Fair |
| Viburnum affine | Downy arrowwood | 1 | Uncommon | Fair | Slight |
| Viburnum alnifolium | Hobble-bush | 12 | Uncommon | Great | Fair |
| Viburnum dentatum | Arrowwood | 1 | Uncommon | Fair | Slight |

[1] Under conditions prevalent at the time of study.
[2] B. lenta and B. lutea present. Similarity of seedling winter twigs prevented separation.
[3] Mostly Q. velutina and Q. borealis.

of but "slight" value. Of the browsings noted, those on the four species of "great" importance, formed 46.5% of the total; on the six of "medium" grade, 30.3%; on the eleven of "fair" quality, 17.4%; while croppings on the remaining 21 species of "slight" value, comprised but 5.8% of the total number of records.

In the event of over-browsing on the range studied, undoubtedly many species now of little value, if abundant,

would become of great importance. Under the conditions prevalent at the time of the investigation, however, the species of "great" and "medium" importance formed the bulk of the browse consumed. Of these the maples, as a group, were of outstanding value.

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SUMMARY

Notes regarding 42 species of woody plants and 2,089 individual browsings upon them by northern white-tailed deer (*Odocoileus virginianus borealis*), were accumulated, incidental to other work, on the Connecticut Hill State Game Refuge near Ithaca, New York, during the winters of 1938–39 and 1939–40. The areas studied involved about 1,000 acres of typical Transition Zone beech-birch-maple-hemlock forest on several sections representative of the entire 4,300-acre upland refuge. The study extended through April and May, 1939 and from December, 1939 through May, 1940.

Excepting for periods of short duration, deer do not yard in the Ithaca region but feed generally throughout the forest which, on the area studied, gave no indication of being over-browsed. During the years cited, deer were not forced by snows to subsist primarily upon browse excepting from early January until late April. Plant species and areas providing succulent twig growth were most sought.

Winter browse species are classified as preferred, staple, emergency, stuffing, and pastime foods (following Leopold's definitions) according to their apparent palatabilities as indicated by utilization. Round-leaved dogwood (*Cornus rugosa*), staghorn sumac (*Rhus typhina*), flowering dogwood (*Cornus florida*), and basswood (*Tilia americana*) were the principal preferred species, while red maple (*Acer rubrum*), sugar maple (*A. saccharum*), striped maple (*A. pennsylvanicum*), witch-hazel (*Hamamelis virginiana*), oak (*Quercus*), and birch (*Betula*) comprised the more important staple foods. The principal emergency foods appeared to be hemlock (*Tsuga canadensis*), white pine (*Pinus strobus*), red pine (*Pinus resinosa*), Scotch pine (*Pinus sylvestris*), and beech (*Fagus grandifolia*). Of the total browsing recorded, preferred foods formed 21.8%; staples, 61.1%; emergency, 14.5%; and miscellaneous 2.6%.

Detailed information regarding the food plant species and their relative importance under the conditions of the study area is presented in tabular form. The availability as well as the utilization of the plant species is taken into consideration. Red maple (*Acer rubrum*), sugar maple (*A. saccharum*), staghorn

sumac (*Rhus typhina*), and witch-hazel (*Hamamelis virginiana*) were considered to be of greatest importance, 46.5% of the total browsings recorded being of these species. Large-toothed aspen (*Populus grandidentata*), quaking aspen (*Populus tremuloides*), birch (*Betula*), oak (*Quercus*), round-leaved dogwood (*Cornus rugosa*), and striped maple (*Acer pennsylvanicum*) were of "medium" quality and comprised 30.3% of the total, while eleven species of "fair" importance and 21 of "slight" value formed 17.4% and 5.8% respectively, of the browse noted consumed.

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# A WATER PLANT CENSUS TECHNIQUE

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The food habits of waterfowl and the management of areas to make them attractive to ducks and geese have both received considerable attention during recent years. This has required an increased knowledge of the ecology of water plants. The purpose of this article is to describe a technique the author has used with satisfactory results in establishing the ratios of abundance of water plants. A knowledge of these proportions is especially useful as a supplement to analyses of stomach contents, for in order to learn food preferences it is necessary to know not only which foods have been eaten in largest quantity, but also the degree to which these were available. To those who wish to manage lakes or marshes for waterfowl, furbearers, or even fishes, an accurate knowledge of plant ratios can be very useful. The wildlife carrying capacity of such areas might be raised by adjusting ill-proportioned plant communities.

The present study of water plants was conducted in eastern Texas where there is an abundance of small artificial lakes seldom exceeding 500 acres in size. There are also a few marshes and a number of bottomland sloughs or backwater lakes. As the plant census progressed, it became evident that the method would have to vary for the differing types of lakes. Plant growth may line the shore in a uniform circle or in irregular growths. The vegetation may cover the entire lake or it may grow in patches. Major differences in plant communities or formations are illustrated in the accompanying sketches (Figs. 1–5). For the sake of simplicity, each type of lake or marsh sketched is assumed to have only four species of water plants (each represented by a different symbol).

The census methods are fundamentally the same for all vegetative types, linear and transect counts being used.

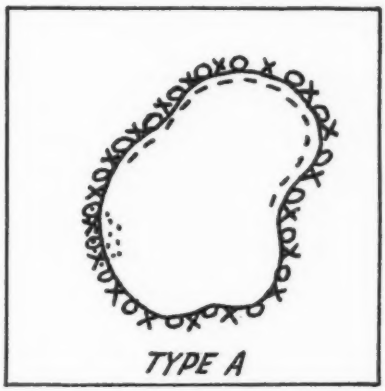


Fig. 1. Lake in which the band of vegetation around the shore line is of fairly uniform width.

It should be understood that the purpose of this technique is not to obtain an enumeration of the number of specimens, but of the surface coverage of each species. Let us suppose, for example, that a lake of type "A" (Fig. 1) has been selected for the census. Having determined that the shoreline band of plants is of rather uniform width around the entire lake, a list is made of all of the species. One next decides whether it is necessary, for adequate sampling, to pace the entire border of the lake or whether a certain segment will be suffi-

cient. The paces or steps are made as short as possible—it is best to place one foot directly ahead of the other—to assure representations of the scarcer

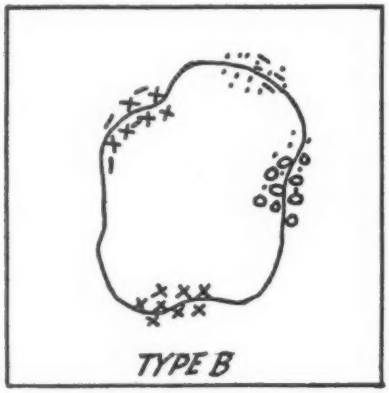


Fig. 2. Lake with irregular growths of vegetation along the shore line.

plants. Do not attempt to census more than two species at a trip. In the theoretical lake under consideration, where but four species occur, two trips will thus be necessary. Tally registers are almost indispensable. One is used for each species to be counted and every time it occurs opposite your foot, count one. Let us suppose that the lake has a circumference of 1,000 steps. Two species occur along the entire shore line. They will thus each receive a rating of 1,000. One species present half the distance around the lake gets a rating of 500. The fourth occurs in a small patch of but ten steps. These plants will then be present in the proportions of 1,000, 1,000, 500, and 10 or approximately, 40 per cent, 40 per cent, 19.5 per cent, and 0.5 per cent.

More difficult is the census of a type "B" lake (Fig. 2). However the linear census used on type "A" is also employed. To take care of the varying width of the plant growth, transect counts become necessary. If for instance a part of the shore line has a formation similar to that illustrated in Figure 3, a linear count would first be made and then it would be necessary to step off the width of the body of vegetation. To obtain an average, this should be done at least once where the width of the plant growth is greatest (transect a) and once where it is narrowest (transect b). The average of these two counts is then multiplied by the linear count. Let us say that the linear count for two plants (x's and dots) is 200. The count at transect (a) for the former is five and for the latter twenty, and at the other transect, seven and eight respectively. These species will be present in the following proportions: x's = $5 \times 7 \div 2 = 17.5 \times 200$ or 3,450, and dots = $20 \times 8 \div 2 = 80 \times 200$ or 16,000 (18 per cent and 83 per cent).

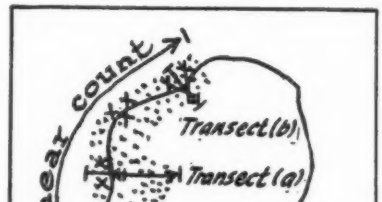


Figure 3

On a large lake where it would be impracticable to step off the entire shore line, one should select sample strips, always of the same length. The sample areas should include all species

occurring in the lake. The more such strip counts are made, the more accurate will be the results. Where concentrations of first one species and then another occur, accuracy of the census will be increased if a rough estimate is obtained of the ratio of one colony to the other by pacing the shore line. If for example a lake with a variety of species, including smartweed and spike-rush concentrations is chosen for a census, and a shore-line survey indicates that these two plants are in an approximate ratio of 20 per cent smartweed to 80 per cent spike-rush, it will be necessary to make four detailed strip censuses past spike-rush concentrations to every one past smartweed.

In a type "C" lake or marsh (Fig. 4) where plants cover most of the area, both linear and transect counts must be made just as on a lake of type "B." In this case, however, the transect counts should extend entirely across the area, and the strips must be kept within a maximum width of good visibility. If the marsh or lake is large, sample strips, always of the same length, are used. In censusing this type of lake, submerged plants may often cause trouble. Plants such as coontail (*Ceratophyllum*), water milfoil (*Myriophyllum*), and bladderwort (*Utricularia*), are often so intermingled that it is impossible to census them separately. In some cases it is best to lump such intermixtures. In others, however, quadrat counts may supplement and clarify the transect counts.

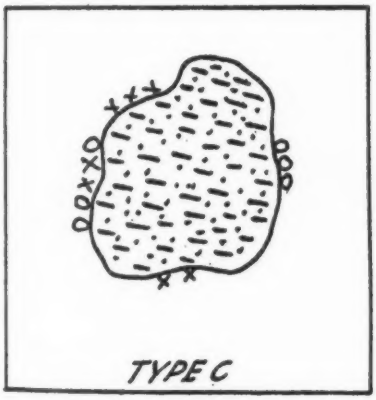


Fig. 4. Lake or marsh in which several species of plants grow rather uniformly over the entire area.

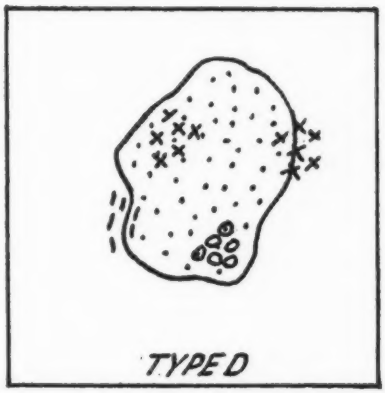


Fig. 5. Lake or marsh in which concentrations of different species occur over the area.

In marshes or lakes of type "D" (Fig. 5) where the general plant growth is interspersed by occasional patches of different species, the census method will again be similar to that used on lakes of type "C." In this case the transects must run through patches of mixed growth. Again, the approximate ratio of species concentrations to the rest of the plant growth will be in proper proportion.

Periodic censuses should be made to reflect seasonal variations in plant growth.

Attention is directed to another water plant census method described in a Russian publication by V. T. Generosoff: "The culture of food and cover plants for waterfowl." This article was abstracted in Wildlife Review, No. 3, April 1936, pages 17–18.

These census methods may be a valuable supplement to certain other methods used by ecologists. In some places, particularly in Illinois, biologists have used aerial photographs of marshes and lakes covering considerable territory with excellent results in making quantitative analyses of plant communities. Different plant zones can be distinguished on the prints to the extent that planimeter measurements are possible. To get the ratios of plant species within the communities, however, the technique described in this paper can be used.

This, however, has certain weaknesses:

1. In cases where but one or several specimens of a species are found, each occurrence is counted as "one" the same as where numerous specimens occur to each step.

2. The method becomes impossible in water too deep to wade. If the plants can be identified from a boat, the number of steps it would have taken to traverse the patches may be estimated and the results then multiplied by the linear count.

3. In deep or very murky water this census technique is not usable.

Despite these weaknesses, the method produces results far more accurate than can be obtained through eyesight estimates.

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# THE EFFECTS OF WINTER ELK BROWSING, SOUTH FORK OF THE FLATHEAD RIVER, MONTANA[1]

*William S. Gaffney*

The National Forests in Region 1, seventeen in number and covering more than 23 million acres in South Dakota, Montana, Idaho, and Washington, contain most of the forest area of the Northern Rocky Mountains. These Forests serve various purposes, including timber production, grazing, recreation, watershed protection, and wildlife conservation.

Of recent years particular attention of forest officers has been directed toward wildlife problems, partly because of increased public interest, and partly because of an unprecedented increase in numbers of big game animals. In ten years from 1926 to 1936 (U.S.D.A. 1926–36) elk have increased from about 15,000 to more than 32,500. Although part of this growing estimate may be attributed to more accurate methods of census, some of it is undoubtedly caused by a natural increase in the herds. Coincident with the multiplication in numbers of elk there has been a deterioration of many of the winter ranges, and recognition of the need for larger areas of winter range if these animals are to be maintained. Concentrations of elk on these ranges have made the following national forests the focal points of attention, with estimated numbers of elk as indicated; the Flathead, 4,500 head; the Lewis and Clark, 4,300; the Bitterroot, 4,000; the Nez Perce, 3,600; the Clearwater, 3,500; and the Gallatin, 3,000.

Most of the elk on the Flathead Forest are concentrated in the drainages of the South and Middle Forks of the Flathead River, in some of the most inaccessible parts of the Forest. Of these, about 2,600 head are in the Big Prairie District in the heart of the Bob Marshall Wilderness Area. Of this area, Shantz (1937) reports, "Probably no more ideal elk range could be found in America than this South Fork of the Flathead Forest." Certainly it is doubtful if there is any area in the country where the animals range under more natural conditions. Roads, cutting operations, farms, and settlements are entirely lacking. The only improvements in this vast wilderness are those absolutely essential to administration and protection of the area.

The Big Prairie District (Fig. 1), upon which this report is based, is a part of what was formerly the South Fork Primitive Area, established in 1933 for the preservation of natural conditions and for the enjoyment of those who wish a wilderness free from modern modes of transportation and habitation. In 1940, the South Fork Primitive Area was combined with the Pentagon and Sun River Primitive Areas to form the Bob Marshall Wilderness Area, in honor of Robert Marshall for recognition of his ceaseless and untiring efforts for preservation of a few remnants of

[1] From a thesis submitted to the Faculty of the Yale School of Forestry in partial fulfillment of the requirements for the degree of Master of Forestry, 1938. A detailed discussion of forest types in the original paper has been omitted, and the hunter kill figures brought up to date.

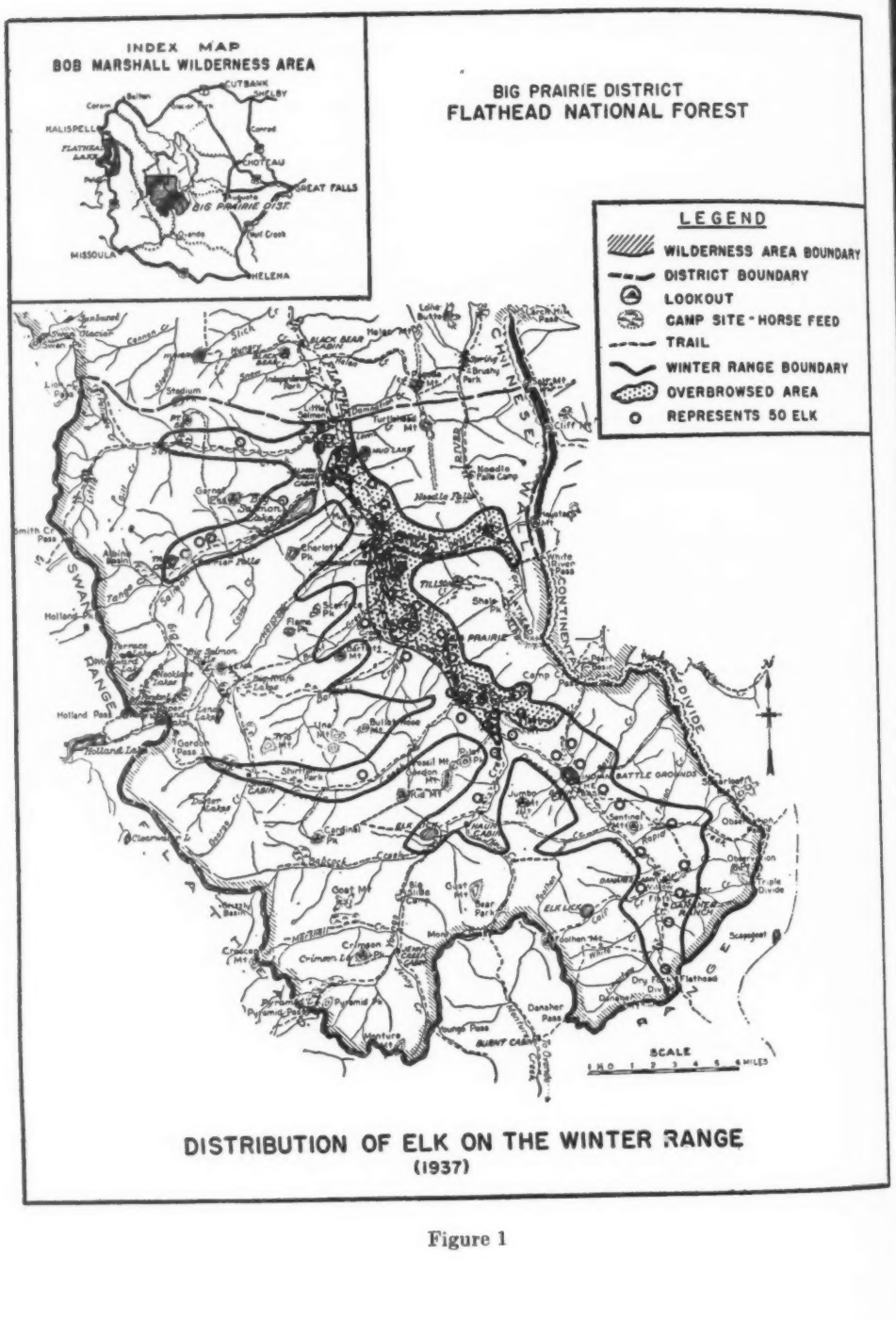

INDEX MAP
BOB MARSHALL WILDERNESS AREA
CUTBANK
SHELBY
KALISPELL
CHOTEAU
GREAT FALLS
BIG PRAIRIE DIST.
MISSOULA
HELENA
BIG PRAIRIE DISTRICT
FLATHEAD NATIONAL FOREST
LEGEND
WILDERNESS AREA BOUNDARY
DISTRICT BOUNDARY
LOOKOUT
CAMP SITE - HORSE FEED
TRAIL
WINTER RANGE BOUNDARY
OVERBROWSED AREA
REPRESENTS 50 ELK
SWAN RANGE
CONTINENTAL DIVIDE
BIG PRAIRIE
SCALE
DISTRIBUTION OF ELK ON THE WINTER RANGE
(1937)

Figure 1

the rapidly disappearing American wilderness. Visitors have access to the area only by foot or horse travel. Four airplane landing fields are maintained only for the purpose of administering the area in the interest of adequate fire control, and are not open to the public. Of the 400 to 600 persons who visit the area annually, more than 90 per cent come by horse. About half of the visitors come during July and August for the purpose of enjoying the scenery, resting, and fishing; the other half come in October and November to hunt big game. From two to four horses per person are almost a necessity. This use requires annually about 200 horse-months of forage on the Big Prairie District. In addition approximately 200 horse-months of forage is required for government stock necessary in administration of the area. Most of this grazing use is concentrated in the lower valleys that form an important part of the winter elk range.

Thus, it can be seen that besides supporting the elk herd, the forage in the area is a necessity in connection with recreational and administrative uses.

The purpose of this report is to present and analyze available data on the forage conditions and factors influencing them on the winter range of the upper South Fork elk herd, such information being vitally needed for the formulation of a plan of land-use management for the unit. As a basis for the study, the writer has spent the greater part of two years in the area in connection with administration of the district, including four months in the winters of 1935–36 and 1936–37 in specific study of the game conditions.

## DESCRIPTION OF THE AREA

### Location and Physiography

The area included in this report is the Big Prairie Ranger District (Fig. 1), an administrative unit of the Flathead National Forest in Montana. It covers approximately 418,000 acres about the head of the South Fork of the Flathead River, in Lewis and Clark, Powell, Missoula, and Flathead counties. The tract, which is extremely rugged, is bounded on the east by the Continental Divide of the Rocky Mountains, and on the west by the Swan Range. A low divide separates the area on the south from the headwaters of the Blackfoot River. Drainage is to the north through the South Fork of the Flathead River. The valley of the South Fork ranges in elevation from about 4,300 feet at the north end of the district to about 5,400 feet at the low divide at the head of Danaher Creek in the south. From the valley floor the mountains rise abruptly to elevations of from 7,500 feet to 8,500 feet in a few miles of horizontal distance. The valley is described by Lewis[2] as being typically an inter-mountain, glaciated valley, subject to much stream action since glacial times, with the valley floor consisting of alluvial first bottom lands, alluvial terraces and fans; and glacial upland, consisting of moraines, rounded knobs, and kettles. The soils are mostly sandy and gravelly with a loose, porous structure. They are almost entirely derived from the whitish limestone and reddish sandstone and

[2] Flathead National Forest 1915. Report on intensive land classification Big Prairie Project, by H. G. Lewis, Soils expert, Bureau of Soils, 78 pp. Typewritten manuscript, Kalispell, Montana.

shales in the geological formations of the area. On the main river, this glaciated floor is from one to two miles wide, narrowing down to a steep canyon at the junction of Young's Creek and Danaher Creek. The valley of Danaher Creek widens again at the mouth of Camp Creek and Basin Creek, and at its headwaters above the mouth of Calf Creek.

In summer, the elk range over the entire district. The winter range is confined to the valley bottoms described above, to the lower of the narrow tributary canyons, and to hillsides to an average elevation of about 6,500 feet on south and west exposures and about 5,500 feet on north and east exposures. The entire area of winter range occupies about 70,000 acres, of which approximately 20,000 acres is used very little by the elk on account of rugged topography, windfalls, and unpalatable vegetation.

## CLIMATE

*General.*—The nearest yearlong station maintained by the U. S. Weather Bureau is at Ovando, Montana, about 40 miles south of Big Prairie, at an elevation of 4,101 feet. Records here (U.S.D.A. 1934–35) show that the mean annual precipitation based on 37 years' observations, is 18.18 inches. Of this, 7.63 inches falls during the warmer season, May to September, inclusive. Precipitation for the years 1934 and 1935 was unusually low, the departure from normal being −3.23 in 1934 and −7.64 in 1935. For these years there was a departure from normal rainfall for the months of May to September of −2.62 inches and −3.51 inches, respectively. The mean annual temperature is 39.0°F., and the mean for the five months, May to September is 54.8°F. The extremes of temperature to be expected in the Big Prairie area are about 95°F., and −40°F., a few records having been made beyond these extremes.

Because of the great and abrupt differences in elevation existing here, it is logical to expect a wide variety of climatic conditions on the Big Prairie District. It is probable that conditions similar to those at Ovando exist in the lower valleys, somewhat modified by the adjacent high mountains. These mountains, holding snows until late in July, probably reduce the mean temperature during the growing season and may, as suggested by Kirkwood (1922), have an effect of increasing the precipitation. During the two summers spent by the writer at Big Prairie, killing frosts occurred every month. Little growth was observed on either the shrubby or herbaceous vegetation until May 1.

The production of forage over parts of the area has undoubtedly been affected by the drought of 1934 and 1935. Studies by Ellison and Woolfolk (1937) near Miles City, Montana, showed that as a result of the 1934 drought the growth of shrubby plants in that area was greatly reduced and that the effect lasted more than one season. Their observations also revealed a great reduction in the growth of herbaceous vegetation. It seems probable that most of the effects of the drought on the winter range in the Big Prairie area would be on the vegetation of the upper benches and the hillsides, the lower bottoms which produce the bulk of the willow, cottonwood, and aspen browse, being well supplied with water from

the streams. A moderate reduction in volume of feed by drought would not be a major influence on the summer range because of its large area. Such a reduction may assume great importance, however, on the limited area of winter range.

*Winter Conditions.*—Summer temperature and precipitation are of primary importance as they affect the character of the vegetation and its growth. Of far greater importance, however, in influencing the available area of winter range, the relative accessibility of different forms of vegetation in the winter, and the movements of the elk on the winter range, are the snow and temperature conditions of the range during December, January, February, March, and April. Winter game studies since 1934 have indicated that snow to a depth of 18–24 inches usually occurs in late November or early December on the higher ridges and peaks, extending downward to an elevation of about 7,000 feet. This serves to force most of the elk down to the lower parts of the range where the snow depths vary from almost nothing to 6 inches. Shortly afterward, heavy snows make the upper areas inaccessible. The accompanying Table (1) shows the average snow depth on the winter range reported by game patroleum[3] during the five winter months.

These readings were all taken on the flats, and are representative of the larger part of the winter range. However, on open south and west exposures, there was usually from 6–24 inches less snow. It was observed on February 27, 1937 that the snow stake at Basin Creek recorded 24 inches of snow, while at the same time the elk were feeding on open hillsides two miles away, where the ground was bare. Since the studies in 1937 were confined to eight weeks in January, February, and March, the snow stake readings for that year are not included in the above table. It was observed that the snow depth during these months ranged from 10–40 inches on the flats and from 0–24 inches on the exposed hillsides.

TABLE 1

AVERAGE SNOW DEPTHS BY MONTHS IN INCHES

| *Year* | *December* | *January* | *February* | *March* | *April* |
|---|---|---|---|---|---|
| 1933–34 | 22.00 | 20.16 | 21.91 | 21.76 | 9.00 |
| 1934–35 | 11.03 | 20.07 | 21.20 | 29.16 | 22.92 |
| 1935–36 | 6.50 | 28.50[1] | 37.20[2] | 32.40 | 23.50 |
| Averages | 13.18 | 23.24 | 26.77 | 27.77 | 18.80 |

[1] Figures available only for January 1 to January 15.
[2] Figures available only for February 15 to February 29.

Observations during the five winter months indicated that the depth of the snow increases rapidly at elevations above 5,500 feet on north and east exposures, and above 6,000 feet on south and west exposures. From an average of approximately 40 inches at these elevations, the snow depth ranges to

[3] Flathead National Forest. Report on winter game studies, Big Prairie District, 1934–35, by Orville Sparrow, Asst. Technician and J. R. Hutchinson, Forest Ranger, 37 pp. typewritten manuscript, Kalispell, Montana. Report on South Fork game studies, 1935–36 by Ralph S. Space, Assistant Supervisor, 47 pp. typewritten manuscript, Kalispell, Montana.

between 6 and 8 feet at elevations of 7,000 feet and over. A few wind-swept ridges at elevations between 6,000 and 7,000 feet usually become bare and are occupied by elk during February and March, but the combined area of these is small.

The snow recedes rapidly from the lower slopes on south and west exposures after the first of April, and the flats are usually bare between April 15 and May 1. By this time the snow at higher elevations has usually become hard packed and in some instances the animals are able to travel on top of the snow between exposed patches of forage. The snow usually remains on the sheltered east and north exposures from two to four weeks longer, which has the effect of concentrating the animals on the other slopes.

The amount of snow in which elk can winter successfully depends on several factors:

1. The composition, height, and volume of the palatable vegetation.
2. Condition of the snow, packed, crusted, or loose.
3. Age and condition of the animals.
4. Topography.

Taking these up in the order listed, it can be readily seen that shrubby plants, such as willow, chokecherry, and dogwood are more available in deeper snow than are the grasses and other herbaceous plants. Elk will often nose through 12 to 18 inches of soft snow while feeding on bunch grass and frequently paw to obtain feed at much greater depths. Speaking of the Sun River Herd, Smith, (1930) states that, "Elk will obtain feed in 3½–4 feet of loose snow." In February 1937, six elk were observed by the writer to be pawing through 36 inches of moderately loose snow for marsh sedge. Most pawing, however, appears to be in those areas where the grasses and sedges are relatively dense, as in marshes, meadows, and bunch-grass areas. Generally, it is estimated that a depth of about 30 inches is sufficient to cause the elk to feed largely on browse on this range. At depths of 36 inches, or more, certain low browse species as Ceanothus, Symphoricarpos, and Rosa are covered by snow and become more difficult of access. Under such conditions the dense thickets of willow along the streams and bottom lands offer a large volume of food accessible with a minimum of movement on the part of the animals.

Hard-packed or crusted snow noticeably decreases the depth at which herbaceous plants are available and may force the animals to subsist largely on browse with snow depths of from only 12–24 inches. Such conditions usually occur for one or two weeks in February or March. A rapid thaw followed by heavy freezing, however, usually produces a crust upon which the animals can walk, increasing the area over which they can range for food. Crusted or packed snow which will not support the animals impedes their movements at a lesser depth than loose snow.

Mature elk move without difficulty in loose snow up to about 40 inches in depth and in packed or crusted snow to about 30 inches. At greater depths they are seriously hampered and their range is much restricted. It has been observed that in deep snow the elk usually bunch up and travel single file, different animals breaking the snow from time to time, and thus they are able to move from one patch of feed to another more easily than could a single animal. Al-

though isolated animals have been observed in snow of greater depth, generally it may be said that a depth of 48 inches represents the maximum in which the animals can range efficiently. Calves and older animals in weakened condition cannot usually move freely in depths beyond 30 inches.

The influence of topography is not great until the snow reaches a depth of about 30 inches. An elk will buck 12–18 inches more snow on the flats than on a hillside. Following a heavy snowfall, therefore, the tendency is for the animals to be forced down toward the flats.

Obviously, since feeding by man is out of the question in this area, it is the conditions during the most severe, rather than those during the average, winter that determine the extent of the winter range on which to base the carrying capacity. In January and February, 1936, extreme conditions were reported at Spotted Bear, 40 miles north of Big Prairie, as follows: "The snow was about 45 inches deep January 15; as it was quite warm the snow settled and was about 33 inches deep February 1 when the real critical period started. This period lasted about 21 days and during that time the snow depth changed from 33 inches on February 5 to 54 inches on February 12. The mean temperature for this 21-day period was −15°F. with a minimum of −52°F. at Spotted Bear Ranger Station." Although there were no game patrolmen at Big Prairie during this period, conditions are usually comparable here to those at Spotted Bear, and it is believed that similar temperatures prevailed, with probably somewhat lesser snow depths.

Temperature conditions are important in that they influence the movements of the elk and the amount and condition of the snow. In the winter of 1933–34, a minimum of −10°F. was recorded. Frequent thaws that melted snow on exposed hillsides were reported that season. The extremely cold weather of the 1935–36 season, with a minimum temperature of −52°F. has been mentioned. At that time it was also observed that during extreme cold the elk moved but little, staying mostly in the heavy timber. In 1937[4] a minimum temperature of −47°F. was recorded on January 20, with temperatures ranging mostly below zero until February 1. At these temperatures, there was little movement of the elk, most feeding being in the green timber and on the protected flats.

## FOREST TYPES[5]

Douglas fir (*Pseudotsuga taxifolia*) forms the predominant forest type on the winter range. It occurs from the lowest elevation to above 7,000 feet in the area, and, except on those sites which are mesophytic enough to support spruce (*Picea engelmanni*) or true fir (*Abies*), is believed to represent a climax association.

The larch-Douglas fir (*Larix occidentalis-Pseudotsuga taxifolia*) type is fairly extensive over the lower parts of the range, occupying a wide belt on both sides of the South Fork, from the north boundary of the district to White River. Larch is probably sub-climax in this as-

[4] Flathead National Forest. Report on winter game studies, Big Prairie District, 1937, by W. S. Gaffney, Forest Ranger, 44 pp. typewritten manuscript, Kalispell, Montana.

[5] For a discussion of the composition of these types, see Larsen (1930).

sociation, owing its presence mainly to fire, as pointed out by Whitford (1905).

The lodgepole pine (*Pinus contorta*) type occurs extensively on the flats and lower hillsides throughout the area; it is an indicator of past fires (Whitford, 1905; Clements, 1910; Kirkwood, 1922). Lodgepole is the principal species restocking old burns, sometimes forming almost pure stands.

The ponderosa pine (*Pinus ponderosa*) type is limited to about 1,500 acres around the mouth of White River and on Murphy's Flat. It is important to point out here that the optimum growing season for ponderosa pine is 200 days or more (Larsen, 1930), and that it is persisting here where the growing season is about 160 days, that is, under distinctly unfavorable conditions.

Spruce forms a forest type in limited areas along river bottoms and on the moister sites on north slopes throughout the area. Where spruce occurs, it undoubtedly represents the climax type, being the most tolerant tree of the district.

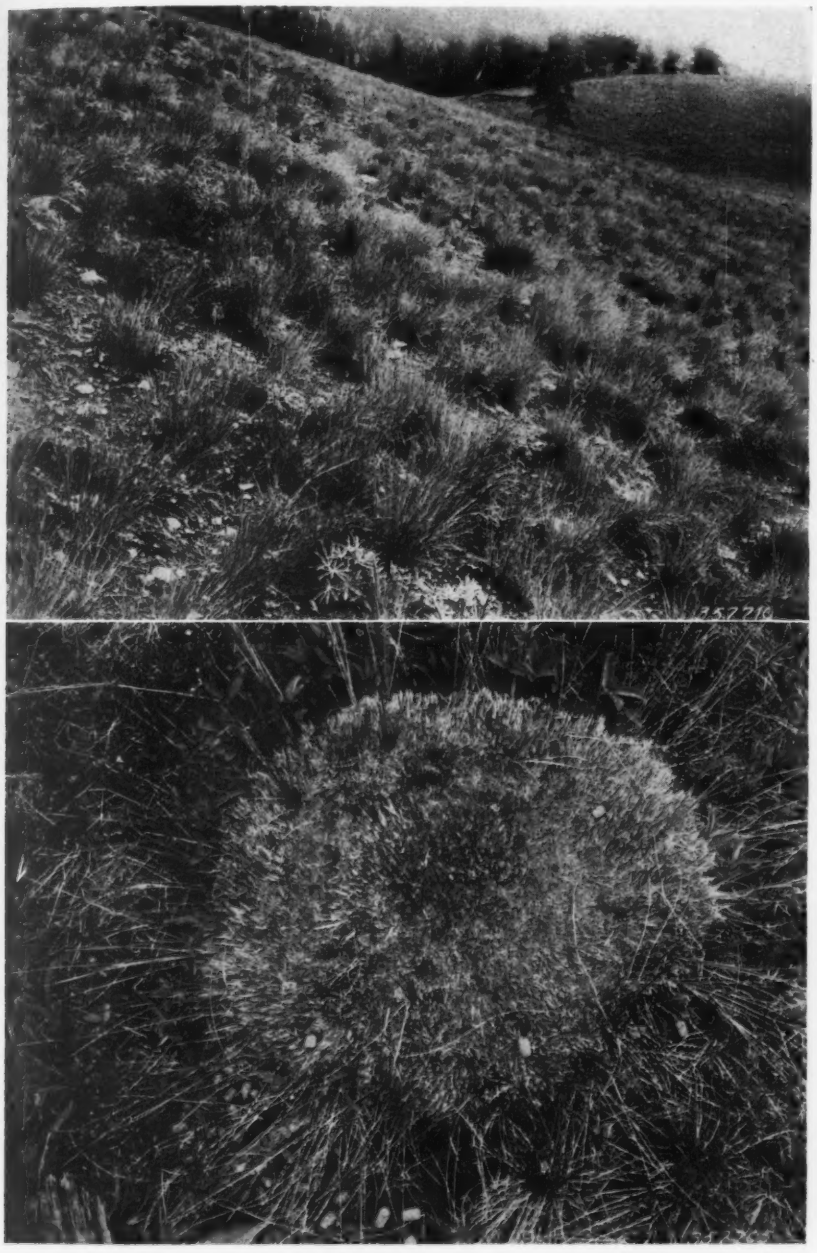
The meadow or grassland type (Pl. 28-A) represents a comparatively small area on the winter range, probably not more than 1,500 acres in the aggregate. It is relatively important because of the high volume of palatable feed it produces. Its occurrence as a type is restricted altogether to the alluvial bottoms and terraces and a few of the morainal uplands.

### TEMPORARY COVER TYPE OR BURNED AREAS

The only area of appreciable size on the winter range that has been burned since 1910 is one that was overrun by fire in 1926; it extends from Hahn Creek about four miles down Young's Creek. This is on a part of the range which, because of deep snows, is little used.

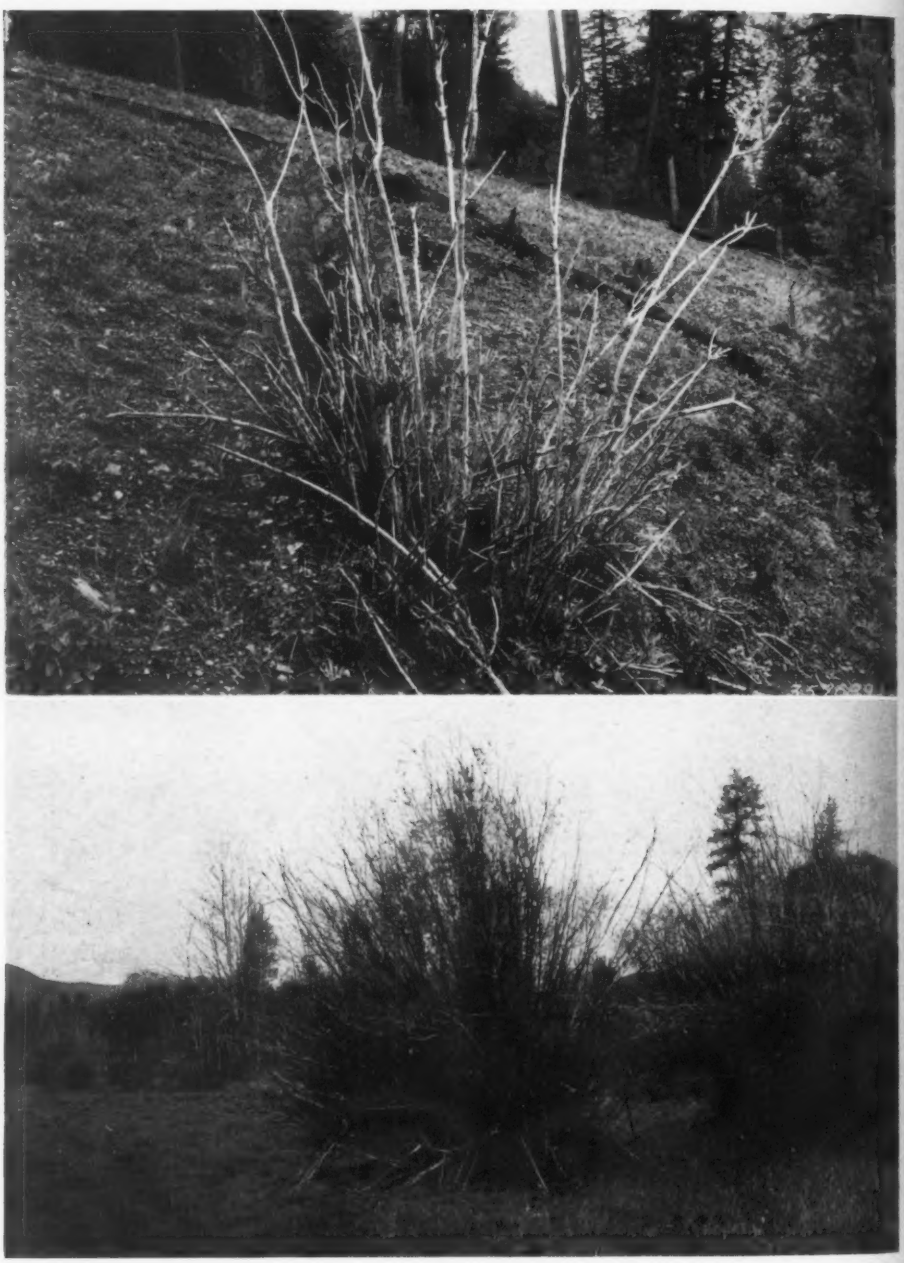
The sweeping fires of 1889 and 1910 burned over most of the valley bottom and hillsides from the mouth of Big Salmon Creek to Burnt Creek, and all but a few hundred acres in White River. In 1889, a large part of the flats around Big Prairie and Basin Creek were burned over by two fires, the combined area covered by which was some 15,000 acres. The Basin Creek flats and hillsides were burned again in 1910. Most of the burned areas are now occupied by lodgepole pine, which has formed a stand averaging probably 35 feet high in the 1889 burns and about 15 feet high in the 1910 burns. Double burns, which are not reproducing, cover small areas of exposed hillsides around the mouth of Phil Creek and on the slopes above Basin Creek.

The succession following fire, the first year, is usually a stand of herbaceous vegetation consisting mainly of fireweed (*Chamaenerion angustifolium*) thimbleberry (*Rubus parviflorus*), bear-grass (*Xerophyllum tenax*), bracken fern (*Pteridium aquilinum*), and dogbane (*Apocynum androsaemifolium.*) These are followed by a dense growth of shrubby vegetation including willow (*Salix*), *Ceanothus velutinus*, *C. sanguineus*, chokecherry (*Prunus demissa*), and mountain maple (*Acer glabrum*). The shrubs dominate the site for from 6–10 years, when they are overtaken and surpassed by conifers. Although the species of conifer seeding in depends largely on what trees were present before the fire, lodgepole pine has a decided advantage in restocking burns, as pointed out by Whitford (1905), Clements (1910), and others.



A (*Upper*)—Native grassland at head of Danaher Creek. Bluebunch wheatgrass (*Agropyron spicatum*). U. S. Forest Service; photograph by H. L. Shantz.

B (*Lower*)—Buffalo bunchgrass (*Festuca scabrella*) damaged by early spring grazing by elk. Lower Cayuse Creek. U. S. Forest Service; photograph by H. L. Shantz.



A (*Upper*)—Illustration of preference of food by elk. Willow in foreground killed by winter browsing; Douglas-fir reproduction unbrowsed. Near Big Prairie. U. S. Forest Service; photograph by H. L. Shantz.

B (*Lower*)—The inner stems of this large willow near Big Prairie have reached a sufficient height that they are protected from browsing. The outer stems have been killed by winter elk browsing. U. S. Forest Service; photograph by H. L. Shantz.

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er elk

### RELATION OF COVER TYPE TO WINTER FEED

As has been pointed out, the largest volume of winter feed per unit area is in the grass type (Pl. 28-A). The ponderosa pine type as it exists today is a close second, by virtue of producing an abundance of three grass species. Each of these types, however, is relatively limited in area, and cannot alone be depended upon to furnish all the feed required. The Douglas fir and larch-Douglas fir types are essentially similar in the amount of feed produced, both having Scouler willow (*Salix scouleriana*), serviceberry (*Amelanchier alnifolia*), chokecherry, mountain maple, and huckleberry (*Vaccinium*) in the shrub layer, with an abundance of pine grass (*Calamagrostis rubescens*) on the ground; both grade into thickets of juniper (*Juniperus scopulorum*), willow, and cottonwood (*Populus trichocarpa*) bordering the streams and beaver ponds. The lodgepole type at young ages occasionally forms such dense stands as to exclude most other forms of vegetation, but the stands are frequently open, with patches of grass and sedge (*Carex*) intermingled with aspen (*Populus tremuloides*). As the pines mature, pine grass develops under the canopy. Where the lodgepole type encroaches upon moister sites, it too supports willow, cottonwood, and juniper. The spruce type, occurring only as a narrow belt along the streams, covers a relatively insignificant area of the winter range. It usually occurs in broken stands, associated with beaver workings. Willow, dogwood (*Cornus stolonifera*), and cottonwood form dense thickets in the openings.

Fires may provide temporarily a large volume of browse that might support many times the elk that the destroyed coniferous stands could maintain. The fallacy in thinking that burning increases the carrying capacity of the range lies in the fact that the brush is but a short-lived type. Burned repeatedly, it may leave a barren, desolate site incapable of supporting a palatable forage that will protrude above the snow. The urgent need for fire protection in these "back country" areas, discussed by Loveridge (1935) and others, need not be gone into here. It is sufficient to point out that green forest on the slopes is one of the main features enhancing the enjoyment of the primitive area by recreationists. Loss of the forest would be a greater misfortune than loss of the elk.

Even in the mature climax forest, there is some feed for elk; the closing in of the stands, as natural succession follows fire, reduces the volume of palatable forage, but never to the point of exclusion. It must be remembered that this is a region with only 18 inches of precipitation annually, an amount dangerously near the minimum for tree growth (Larsen, 1930; Whitford, 1905). On a water ration the forests tend to develop a more or less open formation that permits the presence of a few relatively shade-intolerant shrubs and herbaceous plants. Seldom, if ever, do we find on the forest floor here an "ecological desert" such as is described by Leopold (1936) as occurring in certain deer forests in Germany.

## HISTORY OF THE HERD, PRESENT NUMBERS AND DRAIN

### EARLY RECORDS

It seems probable that there were elk in the Big Prairie District before the

animals were driven from the plains by the coming of the white man.

In a discussion of winter game studies, 1935–36, it is stated that, "In the latter part of the 1840's, a battle took place at the mouth of Camp Creek between the Blackfeet and Flathead Indians, the Blackfeet attacking a camp of the Flatheads. Although legend does not say what the [intruding] Indians were doing here it is very probable that they were hunting elk." This story is partly confirmed by the accounts of early travelers in the area, who reported finding evidence of the battle. Hunting parties of Flathead Indians numbering from 10 to 20 still come into the district every fall from their Reservation, but it is believed that the numbers coming to hunt were greater in the early days. Hunting regulations and bag limits also have undoubtedly had an influence on the number of elk killed by Indians. Urquhart and West[6] state that, "The Flathead Indians were probably the first hunters to enter the area to any extent. This region was included in their original tribal holdings. It was probably their chief summer hunting ground for at least a century. These Indians formerly established summer camps in the mountains and remained for weeks hunting elk and drying the meat which was carried to the Flathead Valley by pack train." It is also reported that in 1876 a Colonel Sievers made a trip through the South Fork and killed elk near Mud Lake where the animals were plentiful.

Whether or not the elk then wintered in the area is a matter of conjecture. It is believed that most of them did not. This view does not seem unreasonable in view of the presence of open prairies 30 miles to the east on Sun River and 20 miles to the south on the upper Blackfoot River. Elk in other areas, the Yellowstone, for example (Graves and Nelson, 1919; Preble, 1911; Rush, 1932), migrate much greater distances from summer to winter range. As the elk were driven farther back into the mountains by the advance of settlement on the Sun River and upper Blackfoot, those individual animals, which had previously migrated, gradually died out, and their progeny no longer knew the way to the old winter ranges. Thus, even if those lands were made available to the elk today, it would probably be many years before their use would become established.

The first record we have of elk wintering in the South Fork was in the winter of 1899–1900, when Frank Haun, forest ranger, reported that approximately 80 head remained in the vicinity of Big Prairie, and that about 20 of them died of starvation. He stated further that there was an abundance of willow browse in the vicinity. This information was supplied by W. W. White of Missoula (White, 1938) who interviewed Haun in November, 1937. In a recent letter from Mr. White, he states that Haun said further that the winter was one of unusual severity, with deep snows and heavy crusts.

## ESTIMATED NUMBER OF ELK

The present number of elk in the area is estimated to be about 2,600. Figure 1 shows the approximate distribution of the elk according to observations made

[6] Flathead National Forest. Informational report and recommendations, by J. C. Urquhart, Forest Supervisor, and Raymond M. West, Wildlife Technician, 24 pp. typewritten manuscript, Kalispell, Montana.

during the past four winters when the animals were concentrated on the winter range. A census was taken by two men each winter, covering the entire area once a month. Accurate counts could be made of the animals in the burned-over and other open areas. Estimates were made of the number of elk in the timbered areas, on the basis of tracks and condition of the forage. Considering the size of the district covered by the game studies, about 70,000 acres, the large possibility of error in the estimate must be admitted. It is believed, however that the figure is conservative. The tremendous difficulty of obtaining an accurate census can readily be appreciated when it is realized that the animals often run when men approach within a quarter of a mile. The only opportunity for a close check comes when a heavy snowfall causes the elk to herd together and makes it possible for observers to get near. Such conditions have not occurred for a length of time sufficient to enable the men to take advantage of them and cover the entire area since the game studies were begun in 1933. Each winter, elk have been discovered in parts of the range where they had not been seen before.

### ANNUAL KILL AND WINTER LOSSES

The increased kills since 1936 (Table 2) are believed to have been brought about by the wide publicity given to the opening of the Spotted Bear Game Preserve, and to the presence of larger numbers of elk, as well as to a longer hunting season. The kill is still short of the number that should be removed.

The reason for the record of more elk being killed than there were hunters present in 1933 and 1934 is probably due to kills in excess of the bag limits attributed to parties of Flathead Indians.

TABLE 2

| *Year* | *Kill* | *Number of Hunters* |
|---|---|---|
| 1931 | 130 | 159 |
| 1932 | 114 | 138 |
| 1933 | 100 | 95 |
| 1934 | 100 | 90 |
| 1935 | 50 | 88 |
| 1936 | 155 | 210 |
| 1937 | 237 | 275 |
| 1938 | 251 | 310 |
| 1939 | 184 | 280 |
| 1940 | 310 | 340 |

The first heavy winter losses were reported in a 1932 game report: "It is estimated that between 500 and 1,000 head of elk died of starvation in the yards from the mouth of White River to Cayuse Creek." Although there are no climatic records for that winter, it is believed to have been one of unusual severity. Heavy losses were next reported in 1936, when it was estimated that at least 400 elk died; about 275 of the animals died in the spring of 1937.

## BIOTIC AND OTHER INFLUENCES

### THE SPOTTED BEAR GAME PRESERVE

The building of a road from Coram to Spotted Bear Ranger Station was started in 1921, and there was a widespread feeling that the road would facilitate extermination of the elk herd, then estimated at 1,200 for the entire South Fork. This sentiment led to the creation of the Spotted Bear Game Preserve in 1923 by action of the legislature of the State of Montana. The Preserve included all of the area east of the South Fork to the Continental Divide, extending from Spotted Bear Ranger Station southward to Cayuse Creek, two miles

above Big Prairie Ranger Station. Curiously enough, all of the area set aside was beyond the end of the new road. Thus was eliminated the factor of reduction by hunting from the survival equation of a large part of the Big Prairie elk herd. However, upon recommendations by sportsmen, officials of the State Fish and Game Commission and the Forest Service in recognition of severe damage to the winter range, the Spotted Bear Game Preserve was opened to hunting in 1936.

### EFFECTS OF PREDATORS

Mountain lions were formerly common in the area, several having been killed by forest officers and others in the vicinity of White River and Mud Lake between 1920 and 1930. At the request of the Forest Service, in 1923 a Biological Survey hunter was detailed to hunt mountain lions, and since that time the numbers of this species have decreased until only two tracks, possibly those of the same animal, have been seen on the district in the last three years. It may be that the pumas were killed out to the point where any increase in numbers is now dependent on immigration. Several instances of mountain lions killing elk calves were reported in the early days, but it is not certain just how important a factor the lions were in keeping the herd down.

Coyotes have been present in the area since the earliest records. Their present number is estimated at about 250. Although these animals undoubtedly kill a few calves and weakened animals, it is believed that they are not an important factor in controlling the elk herd.

Grizzly bears have been known to kill elk in the Big Prairie area, but not in such numbers as to be considered important. It is estimated that there are about 30 grizzlies here at this time.

No records are available to indicate the presence or absence of wolves in the area in the early days. A few tracks have been reported but so far as known, none of the animals have been seen.

No special control of predators, such as the early lion campaign, is contemplated under the present policy. Grizzly bears are protected in part of the area, and their hunting is subject to a closed season on the remainder of the range with a bag limit of one animal per person. Other predators are not protected.

It seems doubtful that any predator will have a sufficient controlling influence on the elk to justify stocking the area with the species. Then, too, it must be considered that the predators might spread to nearby stock-raising lands and cause serious losses.

### INFLUENCE OF ELK ON ADJACENT AREAS

There is some drift in the winter between the Big Prairie herd and the band of an estimated 1,100 animals on the Spotted Bear District immediately north, but from the indications by tracks in the winter, it is believed that this trend is slight.

The Sun River herd, estimated at about 3,000 head, occupies the area immediately east of the Big Prairie District and is separated from it by the Continental Divide, an impassable barrier because of snow conditions from about December to April each year. Several hundred elk, representing both the Sun River herd and the South Fork herd, range along the top of the Divide

in late fall and may be forced down on either side by a heavy snowfall.

About 100 head winter in the Dry Fork of the Blackfoot River, immediately south of the head of Danaher Creek, and some of these elk mingle freely with those on the Flathead side.

### FACTORS CONTRIBUTING TO THE OVERSUPPLY OF ELK

The factors that have led to the rapid increase of elk in the Big Prairie area are summed up by Urquhart and West as follows:

"1. The inaccessibility of the area. (Two days' pack trip required to reach it.)
"2. The difficulty of travel to or from the area in the case of snow storms blocking the high mountain passes.
"3. The establishment of the Spotted Bear Game Preserve.
"4. The almost complete extermination of the mountain lion."

It is believed that a probable additional factor may be the decreasing number of Flathead Indians coming to hunt in the area, since the institution of hunting regulations.

### USE OF FORAGE BY ANIMALS OTHER THAN ELK

It has been previously pointed out that about 400 horse-months of forage, mostly grass, are required by the government and recreationist stock using the area in the summer.

There are estimated to be about 200 mule deer in the area, whose numbers are kept about constant by coyotes. The deer are scattered over the winter range in small bands and it is believed they do not have an important influence on the amount of forage.

Beavers are numerous in the area and feed on the cottonwoods and willows along the streams. The presence of beavers, however, is advantageous to the elk, since by building dams and diverting streams from their channels they flood areas that produce an abundance of willow and other palatable browse.

### PARASITES AND DISEASES

Studies to date have been inadequate to determine the effects of various parasites and diseases. Livers from mature elk killed during hunting season are frequently infested with the liver fluke (*Fasciola*). Wood ticks (probably *Dermacentor albipictus*) are found on most of the animals after February, and in some instances the death of young elk has been attributed largely to these infestations. Other parasites that have been found in the elk are the deer botfly (*Cephenomyia*), and a species of tape worm. A calf elk that was found dead in March, 1937 apparently died of pneumonia. It is seldom that a dead animal is found in such condition that it is possible to perform an autopsy, the carcasses being rapidly consumed by coyotes.

## THE EFFECTS OF WINTER BROWSING

### FEEDING HABITS AND FORAGE PREFERENCES

Elk are fundamentally grazing animals. Under natural conditions they feed mostly on grasses and other herbaceous plants, browse making up only from 10–20 per cent of their diet. Observations on the Flathead, and other

areas[7] show that when grasses, sedges, and other herbaceous plants are available, they are taken in preference to other forms of forage (Rush, 1932). That elk can and do, however, subsist largely on browse when necessary is exemplified over much of the Flathead. Browse is estimated to form 60 per cent of the winter diet of the elk on part of the Bitterroot National Forest and 90 per cent on parts of the Nez Percé Forest.

The most favored feeding spots in the South Fork are the open hillsides on south and west exposures. These sites are naturally preferred because the snow is less deep there than in any other part of the range, allowing the elk greater freedom of movement and making the forage more available. The elk on this winter range feed in the daytime as well as at night, as opposed to Rush's (1932) observations on the Yellowstone. It may be, however, that daytime feeding is an unnatural condition brought about by shortage of feed.

The elk usually feed in bunches of from 10 to 60 (sometimes larger), often covering a mile or more in the course of a day's foraging. This habit of feeding in large bands, as pointed out by Lantz (1910), is favorable to their preservation. An unusually heavy snowfall may restrict the whole herd to a small area of inadequate range. Because of the habit of feeding in bunches, and because of the tendency to concentrate in areas of least snow depth, we may expect to find localized areas overgrazed on any part of the winter range. It is only by careful inspection of the whole unit that we can determine whether there is a general retrogression.

Dayton (1931) states that the primary meaning of the word "browse" is "shoots or sprouts, especially of tender twigs and stems of woody plants, with their leaves, as cropped (browsed) more or less by domestic and wild animals." The characteristics of an excellent browse species, following Dayton, include high palatability and nutritiousness; height (within the reach of livestock); ability to withstand grazing (size and extent of the root system, vigor and aggressiveness, etc.); reproductive power; freedom from anatomical structures such as spines and awns that may be injurious or annoying to grazing animals.

Palatability is defined (U.S.D.A. 1935) as "the degree to which the herbage within easy reach of the stock is grazed when the range is properly utilized under the best practical range management. The percentage of the readily accessible herbage of a species that is grazed when the range is properly utilized determines the palatability of the species." In studying browsing on winter range the word "herbage" must be modified to include the last year's growth of woody plants. Palatability of any species depends largely on the association in which it occurs. Thus, aspen in a grass range may scarcely be touched; occurring again on a range made up mostly of browse species, it may be eaten in preference to all other plants.

The plants on the winter range on the

[7] Lewis & Clark National Forest. The Sun River Elk Herd Report, 1935, by L. J. Howard, Forest Ranger, and R. F. Cooney, Range Technician. Typewritten manuscript, Great Falls, Montana.

Big Prairie District may best be grouped according to palatability by two areas: (1) That part of the range on Danaher Creek from its headwaters to its junction with Young's Creek; and (2) the remainder of the range, including Young's Creek and the South Fork and its tributaries from the mouth of Danaher Creek northward. The first part represents about one-third of the gross area of winter range. It includes most of the grass type and an additional 200–300 acres of grasses and sedges in small openings in the forest. Willows and aspen are abundant. On the second division there is less grass range. Willow, chokecherry, serviceberry, mountain maple, aspen, cottonwood, and other browse species make up the greater part of the forage.

Browse is entirely different in winter than in summer. In the warmer season the bulk of the forage on a browse range is made up of succulent leaves and young twigs. In the colder part of the year, leaves, except those of conifers, are gone and the browse consists of twigs, branches, and young shoots, all of which have become more or less woody. Generally, if the leaves of a plant are palatable, so are the twigs and branches but there are exceptions, such as alder.

Since palatability ratings are based on observations made during proper utilization of the range, the degree of consumption of various species on overbrowsed range does not give an accurate picture of palatability. The acceptability of plants shown in Table 3 is in relation to an estimated proper utilization rather than to existing conditions.

## FORAGE REQUIREMENTS

The actual amount of forage required by an elk has not been definitely determined. From data gathered on a grass clipping plot on the Lewis & Clark Forest,[8] it was estimated that elk consumed slightly more than 21 pounds of grass per animal per day, from December through March. For comparison, it may be cited that moose averaging considerably larger than elk, were found by Hickie (1936) to require about 25 pounds of mixed balsam and birch browse per day on Isle Royale, Michigan. He also reported that the amount increased with the size of the animal and with the severity of the weather. It seems logical to assume that the forage requirements of elk, too, would increase with severe climatic conditions, as deep snow and extreme cold. Thus, the same factors that increase the food requirements also decrease the availability of food.

The acreage required per animal varies, of course, with the density and palatability of the vegetation. On the willow flats it would be considerably less than in the mature Douglas fir forest. Ideally the range should include open hillsides, with heavy timber and dense willow flats where the elk could concentrate following heavy snowfalls. Under such conditions, in upper Danaher Creek, an estimated 300 elk occupy approximately 6,000 acres or 20 acres per head. Equally favorable food supplies are not found on any other part of the range. In the mature larch-fir and lodgepole forests around Big Prairie, 80 acres

[8] Lewis & Clark National Forest. The Sun River Elk Herd report, 1935, L. J. Howard, Forest Ranger and R. F. Cooney, Range Technician. Typewritten manuscript. Great Falls, Montana.

TABLE 3

PALATABILITY[1] AND ABUNDANCE[2] OF PLANTS ON THE WINTER RANGE

| Species | Danaher Creek Area | | Remainder of Range | |
|---|---|---|---|---|
| | Palatability | Abundance | Palatability | Abundance |
| *Conifers* | | | | |
| Abies grandis | 0 | S | 0 | M |
| Abies lasiocarpa | 0 | A | 0 | A |
| Juniperus communis | 0 | M | 2 | M |
| Juniperus scopulorum | 1 | M | 5 | P |
| Larix occidentalis | 0 | A | 1 | A |
| Picea engelmanni | 0 | A | 0 | A |
| Pinus contorta | 1 | A | 2 | A |
| Pinus ponderosa | 1 | R | 2 | M |
| Pseudotsuga taxifolia | 1 | A | 2 | A |
| *Broadleaved trees* | | | | |
| Populus tremuloides | 20 | A | 60 | A |
| Populus trichocarpa | 20 | M | 50 | P |
| *Shrubs* | | | | |
| Acer glabrum | 30 | M | 60 | M |
| Alnus tenuifolia | 0 | M | 2 | M |
| Amelanchier alnifolia | 30 | S | 60 | R |
| Arctostaphylos uva-ursi | 0 | M | 1 | M |
| Artemisia tridentata | 0 | S | 0 | R |
| Betula fontinalis | 2 | S | 10 | S |
| Betula glandulosa | 1 | P | 5 | P |
| Ceanothus sanguineus | 40 | S | 60 | S |
| Ceanothus velutinus | 10 | R | 30 | R |
| Cornus stolonifera | 20 | P | 40 | P |
| Dasiphora fruticosa | 1 | P | 3 | P |
| Elaeagnus commutata | — | None | 60 | R |
| Ledum glandulosum | 0 | S | 0 | S |
| Lepargyrea canadensis | 0 | M | 1 | M |
| Linnaea borealis | 5 | P | 5 | P |
| Lonicera involucrata | 5 | M | 40 | M |
| Odostemon aquifolium | 5 | M | 10 | P |
| Pachistima myrsinites | 15 | A | 30 | A |
| Philadelphus lewisii | — | None | 40 | S |
| Prunus demissa | 30 | S | 60 | M |
| Rhamnus alnifolia | 0 | M | 0 | M |
| Ribes | 10 | M | 20 | M |
| Rosa | 10 | M | 40 | P |
| Salix bebbiana | 20 | S | 60 | S |
| Salix exigua | 20 | P | 40 | P |
| Salix geyeriana | 20 | A | 50 | A |
| Salix lutea | 20 | A | 60 | A |
| Salix melanopsis[3] | 20 | P | 50 | P |
| Salix scouleriana | 30 | A | 60 | A |
| Salix subcoerulea | 20 | A | 60 | A |
| Sambucus melanocarpa | 60 | S | 70 | M |
| Sorbus occidentalis | 0 | R | 30 | R |
| Spiraea | 5 | M | 5 | M |
| Symphoricarpos albus | 20 | S | 60 | M |
| Vaccinium membranaceum | 1 | P | 20 | P |
| Vaccinium scoparium | 1 | A | 10 | A |
| *Grasses*[4] | | | | |
| Agropyron pauciflorum | 80 | P | 80 | M |
| Agropyron spicatum | 80 | A | 80 | P |
| Bromus marginatus | 70 | M | 70 | M |
| Calamagrostis canadensis | 70 | A | 70 | A |

TABLE 3 (*continued*)

| Species | Danaher Creek Area | | Remainder of Range | |
|---|---|---|---|---|
| | Palatability | Abundance | Palatability | Abundance |
| Calamagrostis rubescens | 70 | A | 80 | P |
| Danthonia intermedia | 50 | R | 70 | S |
| Festuca idahoensis | 80 | M | 80 | M |
| Festuca scabrella | 80 | A | 80 | M |
| Koeleria cristata | 80 | M | 70 | P |
| Phleum pratense | 70 | M | 80 | M |
| Poa canadensis | 70 | M | 80 | M |
| Poa compressa | 80 | M | 80 | S |
| Stipa columbiana | 70 | M | 80 | S |
| *Sedges* | | | | |
| Carex sp.[5] | 80 | P | 80 | M |
| Carex filifolia | 60 | S | 60 | S |
| Carex geyeri | 80 | P | 80 | M |
| *Other herbaceous plants* | | | | |
| Achillea lanulosa | 30 | M | 30 | M |
| Antennaria rosea | 1 | P | 10 | P |
| Antennaria sp. | 1 | P | 10 | P |
| Aster | 10 | M | 10 | M |
| Balsamorrhiza sagittata | 60 | P | 80 | M |
| Chamaenerion angustifolium | 40 | M | 50 | M |
| Eriogonum | 10 | M | 30 | M |
| Fragaria | 20 | A | 40 | A |
| Lithospermum ruderale | 10 | M | 20 | M |
| Lupinus ornatus | 20 | M | 30 | M |
| Penstemon | 10 | M | 20 | M |
| Senecio | 5 | P | 20 | P |
| Solidago | 5 | M | 10 | M |
| Xerophyllum tenax | 1 | P | 5 | P |

[1] See definition on page 440. More recent terminology refers to palatability as "proper use factor."

[2] Plants are listed from abundant to rare as follows: A, abundant; P, plentiful; M, moderate; S, scarce; R, rare.

[3] Not positively identified. May be *S. pseudomyrsinites.*

[4] Only the most important species of grasses and other herbaceous plants are listed; there are numerous others, with varying degrees of palatability.

[5] Marsh sedge, species not identified.

per head would probably not be too liberal an allowance.

## NATURE OF ELK BROWSING

Elk browsing is studied by: (1) Seeing the animals feeding, (2) observing their tracks where shrubs have been browsed, or (3), by examination of the browsed plants. Elk, like other members of the deer family, have no upper incisors, and except in the case of the very tender twigs, leave a ragged end on a stem that has been browsed. In some instances the animals have been observed to chew on the end of larger stems with their molars, again leaving a rough wound. The diameter to which twigs and stems are utilized varies with the species and with the availability of food. Mountain maple, chokecherry, and serviceberry are usually browsed to about one-fourth inch, while the salicaceous plants, willow, cottonwood, and aspen, are frequently browsed to diameters of more

than three-eighths of an inch. In browsing conifers the animals generally take only the leaves and tips of the twigs. Damage by chewing the bark of trees such as aspen can easily be recognized by the tooth marks, (Pl. 30-A) which are clearly evident during the first year after browsing.

The height to which the animals will reach for food appears to be between five and seven feet, depending on the size of the individual. There is little tendency for elk to stand on their hind legs when reaching for feed overhead, as is often done by deer.

Shrubs usually hold the snow rather loosely so that the elk can browse them almost to the ground, whereas young trees which grow singly, such as aspen and cottonwood reproduction, are usually surrounded by firm snow and are consequently less available for browsing.

### DAMAGE TO THE WINTER RANGE[9]

Since 1935 it has been recognized that parts of the South Fork winter range were in an overbrowsed condition. The damage has steadily increased in intensity and area until at this time it is estimated that about 20,000 acres are in a badly depleted condition. This area extends over all the range on the east side of the South Fork from the mouth of Young's Creek to Mud Lake, and is shown on the accompanying map (Fig. 1). It is estimated that from 1,500 to 1,800 elk are concentrated on this area in the winter, and the situation is further aggravated by 400–500 of the animals, mostly cows and calves, remaining there during the summer.

[9] Based on observations up to 1938.

Forsling and Storm (1929) studying browse as summer forage for cattle in Utah, found that if all the current year's growth on the better browse species (birch-leaf mahogany and bitterbrush) was taken by the close of the grazing season, it would result in a decline in vigor and slow dying out of the plants and that if continued long enough, would eliminate this type of forage from the range. Winter browsing on the upper South Fork appears to have a similar effect on certain species there, as will be described later.

The ability of different species to withstand browsing varies considerably. Coniferous reproduction appears to be more susceptible to damage than the broadleaved shrubs, the plants usually dying following the loss of the foliage and the terminal bud. Willow is killed back to the ground by heavy browsing more readily than chokecherry, maple, or serviceberry, but makes a more rapid recovery if the plant is protected before it is completely killed.

Following is a discussion of the degree of damage to the various classes of forage on the Big Prairie Area:

*Grass.*—The greatest damage to grass has occurred through premature grazing and trampling in the spring. It is most noticeable on the flats in the vicinity of Big Prairie Ranger Station, where as many as 75 elk have been seen in one herd in May and June. The results of overgrazing here have been the almost complete destruction of what once was a dense stand of buffalo bunchgrass, (*Festuca scabrella*, Pl. 28-B), and its replacement by *Eriogonum*, *Antennaria*, *Sedum* and other less palatable plants. The bases of dead clumps of bunchgrass scattered over about 500 acres give evi-

dar

had

A (*Left*)—Aspen damaged by elk near Big Prairie. Note toothmarks. Old scars show damage dating back to 1932. U. S. Forest Service; photograph by W. S. Gaffney.

B (*Right*)—Cottonwood (*Populus trichocarpa*) browsed by elk on White River. This tree had a basal diameter of four inches. U. S. Forest Service; photograph by W. S. Gaffney.

A (*Upper*)—Mountain maple (*Acer glabrum*) damaged by winter elk browsing near Phil Creek. Hillside in background burned in 1889 and 1910. Browsing of shrubby vegetation has been a factor in preventing the establishment of tree reproduction. U. S. Forest Service; photograph by H. L. Shantz.

B (*Lower*)—Lodgepole pine damaged by winter elk browsing near Phil Creek. U. S. Forest Service; photograph by H. L. Shantz.

dence of the damage. Idaho fescue (*Festuca idahoensis*) also has been seriously injured. Two exclusion plots, established in 1935, have shown good recovery of the better grasses, while on the outside conditions have become steadily worse, owing to heavy grazing by elk. Inspection in June, 1937 revealed a density of palatable plants inside the exclosures of about .3, while that on the outside was less than .1.

The effect of grazing on the bluebunch wheatgrass (*Agropyron spicatum*) on the hillsides has been a considerable decrease in the density of the grass, but with little change in the ecological composition.

*Willow.*—On the Danaher Creek section, willow is hardly more than ten per cent utilized during the winter. Only the outer fringes of the large willow flats near the mouth of Basin Creek have been browsed, and although browsing is distributed over the whole area of the Danaher Fats, many individual plants there have not been touched.

That part of the winter range lying below the mouth of Young's Creek presents an entirely different picture. Willow on the hillsides, most of which is Scouler's willow, has been about 75 per cent killed by browsing, (Pl. 29-A) along with the chokecherry, maple, and serviceberry. Live plants remaining there are sending up new shoots only from the ground. On the flats, it is estimated that 25 per cent of the willows have been killed. Elk have invaded the frozen beaver ponds, chewing the plants down to the ice. They have waded the river and creeks, eating shoots that projected over the water. A diligent search would be required to find one willow plant that does not show evidence of browsing. Certain species, such as Geyer's willow (*Salix geyeriana*) grow to a height of eight feet or more,[10] and thus the center shoots escape browsing by being out of reach of the elk (Pl. 29-B). Narrowleaf willow (*Salix exigua*) is not used so extensively as the other species, but is considerably damaged in some areas.

An exclusion plot was established in a willow thicket one-fourth mile above Big Prairie Ranger Station in July, 1936. At the time the plants were heavily overbrowsed, and several were dead. This plot was examined in August, 1937 and already showed a remarkable contrast with conditions outside. Willows made a surprising recovery under one year's exclusion, many new shoots being about three feet, and several over five feet, high; outside the plot plants that had barely been alive the year before were dead, and others had shoots seldom exceeding a foot in height.

The very high mortality of the willows indicates that summer browsing has also had an important influence. Examination of the area around Big Prairie showed unmistakable evidence of some of the new shoots having been browsed in June and July.

The importance of willow on this lower part of the winter range cannot be over-emphasized. It constitutes not only a large part of the regular winter diet of the elk, but also a reservoir of surplus feed upon which the animals can depend whenever climatic condi-

[10] Most of the information on the different species of willow has been supplied by Wilfred W. White, of Missoula, Montana, and is contained in his "D, (O) Supervision, Inspection—Flathead" report of December 27,1937, which is not available for general distribution.

tions are of unusual severity. Its presence in reasonably large volume would make it possible for us to call this "ideal elk range." Its loss may result in half of the herd being wiped out in a single winter.

*Aspen.*—Aspen owes its occasional presence in almost pure stands largely to fire, following which it sprouts prolifically from the roots. As succession proceeds it is replaced by conifers (Baker, 1925). On the Big Prairie District it occurs in areas that have been burned within the last 40 years, occurring with the lodgepole pine on the moister sites, and occasionally forming pure stands several acres in extent, as in the vicinity of Cayuse Creek, above Big Prairie. It is gradually crowded out by both lodgepole pine and Engelmann spruce as the old burned areas are reforested.

The wide distribution of aspen makes it probably the second most important browse plant on that part of the range below the mouth of Young's Creek. In the Danaher and Basin Creek areas, where there is an abundance of grass and other forage, it is scarcely touched. Throughout the overbrowsed area, limbs on mature aspen have been browsed to a height of from 7–8 feet. It was estimated in the spring of 1937 that at least 50 per cent of the young aspen between the heights of about 15 inches and 6 feet had been killed by browsing. The lower growths had been saved by the snow. The damage to mature trees from bark chewing is particularly noticeable near Cayuse Creek, about 2 miles above Big Prairie. In this area many trees up to 8 inches in diameter have been killed, and it was estimated that 90 per cent of the others were scarred by tooth marks. (Pl. 30-A). It is believed that the rate of elimination of aspen through succession is being rapidly increased by the browsing; little of the reproduction survives.

Sampson (1919) found that aspen reproduction in central Utah was easily damaged by summer sheep browsing. Due to the intensity of use on the overbrowsed area in the South Fork and to the probability that elk browse the individual plants more heavily than would sheep, an even greater loss may be expected here. However, the damage in Montana occurs mostly in winter.

An exclusion plot was established in the aspen stand on Cayuse Creek in 1936, but in one year very little difference could be discerned in the reproduction inside and outside the plot. Recovery is certainly not so rapid as it was in willows.

*Cottonwood.*—Cottonwood occurs along the streams, beaver ponds, and other moist places in all of the forest types in the area. It is relatively scarce and little used on Danaher Creek. It is plentiful along the South Fork from the mouth of Young's Creek north, and on White River. In these areas little reproduction under six feet in height has escaped damage, consisting in most cases of extreme deformity rather than outright killing of the young trees. When heavily browsed, the trees sprout prolifically from the stem and develop a bristly appearance (Pl. 30-B). Branches on older trees are trimmed as high as the elk can reach, but because of their thicker bark, the cottonwoods are seldom damaged, as are the mature aspens.

Cottonwood constitutes one of the most important foods of the beaver in the area, and on several occasions it has been observed that when a tree was

felled by beavers, it was shortly stripped of twigs by the elk.

*Mountain Maple, Chokecherry, Serviceberry.*—These three species are widely distributed and show about the same degree of use when they occur together. They appear to have high palatability and are extensively browsed even on the Danaher Creek area, where they are relatively scarce. Numerous dead stubs and plants extremely deformed by browsing indicate that these species were formerly an important element in the winter food supply on the overbrowsed area. The usual result of several years browsing is to reduce the plants to a bunch of short stalks about 12–18 inches high (Mountain maple Pl. 31-A).

Regarding the ability of serviceberry to withstand browsing, it is stated in the Range Plant Handbook (Dayton, et al., 1937), that "Repeated nipping of the shoot ends induces a rather dense and bushy growth, which tends to protect the inner foliage, and also permits the central stems to grow beyond the grazing height of livestock. . . . Small shrubs, entirely within the grazing range are, of course, killed by continued close use." In the South Fork, serviceberry is a low shrub and seldom is any part of the plant high enough to escape terminal browsing. Mountain maple and chokecherry occasionally grow to such a height that a few plants are protected as described above, but such individuals are not common. The dense, bristly mass of twigs produced by close browsing does, however, provide some protection for the inner shoots, even when low.

Because of repeated overbrowsing, these three species are producing less forage every year, and have largely been eliminated as an important source of food in the overbrowsed area. The plants, even though badly deformed and stunted, appear to be difficult to kill, and it is believed that recovery would be rapid if the intensive use were checked. The presence of numerous dead plants, however, is a warning that to do much good, relief must come soon.

*Conifers.*—Browsing of conifers, with the exception of Rocky Mountain juniper, is almost entirely restricted to the overbrowsed part of the range. The juniper appears to be the most palatable of this group and has shown signs of overuse on White River for at least three years. It is browsed sparingly even on those parts of the range where forage is plentiful. This species is limited in distribution and makes up a relatively small volume of the total forage.

Ponderosa pine, Douglas fir, and lodgepole pine appear to have about the same degree of palatability. Of these, because of its low-hanging branches on older trees, and because so many of the stands are in the younger age classes, lodgepole furnishes by far the greater bulk of forage. In the last few years a well-defined "elk line" has appeared in the lodgepole stands around Big Prairie, where most of the foliage has been browsed off to a height of from 6–7 feet. On White River a similar line is noticeable in mixed stands of lodgepole pine and Douglas fir. Damage to lodgepole reproduction, extensive in both of these areas, is usually confined to that more than 12 inches in height, lower specimens having been protected by snow. The most conspicuous damage to lodgepole reproduction is on the open hillside just north of Phil Creek, where a stand of young trees in the double burn has been almost

stripped of foliage from the tops to about two feet from the ground, the lower branches apparently having been below the snow (Pl. 31-B). Similar damage may be observed near the mouth of Woodfir Creek and on parts of White River.

Browsing of Douglas fir has been most conspicuous around Big Prairie and Cayuse Creek, where an aggregate of about ten acres of dense reproduction was stripped of foliage during January, February, and March, 1937. Scattered examples of browsing on this species may be seen throughout the overbrowsed range, particularly on the margins of the concentration areas, as Phil Creek.

Ponderosa pine reproduction is almost entirely lacking but whether due to browsing by elk is not definitely established. A search in the vicinity of the mouth of White River and Murphy's Flat revealed the almost complete absence of reproduction under four feet in height. Pearson (1931), studying the recovery of ponderosa pine seedlings from injury by grazing in Arizona, found that the seedlings showed a remarkable ability to recover once the damage ceased. He states, "If severe damage is repeated over a period of several years, height growth is checked and the vitality may be reduced to a point where death becomes inevitable." Because of the fact that ponderosa pine is growing under unfavorable climatic conditions on the Big Prairie District, the application of Pearson's findings may not be entirely correct, but from the lack of reproduction it would seem that the damage is severe.

Larch is browsed sparingly where it occurs, but since most of this species is in the older age classes, damage is negligible.

Alpine fir (*Abies lasiocarpa*) and white fir (*Abies grandis*) are used very lightly, even in the overbrowsed area, and, so far as has been observed, Engelmann spruce is never used. Around Big Prairie and on White River, Engelmann spruce stands out distinctly as being the only tree with foliage extending to the ground, that on all other species having been eaten by elk. This lack of palatability of spruce should give it a distinct advantage on sites where it will grow, owing to the restraint of competition from other species. It is making almost the only reproduction to be seen in the lodgepole and aspen stands on lower Cayuse Creek.

*Other Important Browse Species.*—Elderberry (*Sambucus melanocarpa*) is easily the most palatable browse species on the range, stems being frequently taken to half an inch in diameter. It is so rare, however, as to be unimportant as a source of food. It is probable that this plant formerly occupied a much larger area, and it is evident that the few remaining specimens are being rapidly killed.

*Ceanothus sanguineus* and *Ceanothus velutinus* are abundant only in recent burns. On the overbrowsed range both are used heavily, but of the two, *C. sanguineus* is considerably the more palatable and has been more seriously damaged. On Phil Creek and on White River it has been practically destroyed, being browsed down to the ground in many places.

Dogwood has been heavily utilized wherever it occurs in the overbrowsed area, particularly on White River and Cayuse Creek, but because of its scat-

tered distribution a few plants have escaped altogether and most of the others appear to survive, perhaps because of the wet habitat in which they grow.

Additional species that show heavy use are rose (*Rosa*), silverberry (*Eleagnus commutata*), bearberry honeysuckle, (*Lonicera involucrata*), and snowberry (*Symphoricarpos albus*). Others of less importance are listed in the palatability table (Table 3).

*Non-Palatable Shrubby Plants.*—In this category are alder (*Alnus tenuifolia*), bearberry (*Arctostaphylos uva-ursi*), big sagebrush (*Artemisia tridentata*), shrubby cinquefoil, (*Dasiphora fruticosa*), Labrador tea (*Ledum glandulosum*), buffaloberry (*Lepargyrea canadensis*), and alder buckthorn (*Rhamnus alnifolia*). Use of any of these species indicates an overbrowsed condition of the more palatable plants. Cinquefoil and buffaloberry have been cropped on parts of the overbrowsed range, even to the extent of damage to individual plants. Alder has been browsed on Phil Creek, White River, and at Big Prairie. Alder buckthorn is confined to the more moist places, usually under aspen or spruce, and in no instances has use been observed.

## INDICATORS OF OVERUSE

Jardine and Anderson (1919) list the following as indicators of overgrazing in the order of severity:

1. Predominance of annual weeds and grasses.
2. Predominance of plants that have little or no value for any class of livestock.
3. The presence of dead or partly dead stumps of shrubs.
4. Noticeable damage to tree reproduction.
5. Erosion and barrenness.

Grass on the Big Prairie area has suffered great damage in local spots, as has been discussed. The injury is usually less extensive than that to browse probably because the grass is more protected by snow during the season of heaviest use. Were it not for that fact, grass because of its high palatability, could be preserved only by great reduction in the elk herd. The importance of grass damage as an indicator of overuse by elk is lessened by the fact that over most of the area it is also much eaten by horses during the summer.

Replacement of good browse plants by those that have little or no forage value is naturally a much slower process than the change from highly palatable to non-palatable grasses. Observations to date have shown little increase in the volume of the non-palatable shrubs, such as cinquefoil, buffaloberry, and alder buckthorn, but that increase will occur seems inevitable in view of the heavy use of the palatable shrubs even to the extent of their elimination from parts of the area. If the overuse is not checked, replacement by inferior species will probably be extensive within a few years, and will, as pointed out by Shantz (1937), reduce the area to one poorly adapted to the maintenance of elk. Recovery of the better browse species will be retarded by the increased density of the inferior ones. On exposed slopes where browsing of maple, chokecherry, and ceanothus has been heavy, as on Phil Creek, White River, and Big Prairie, it has been noticed that there has been a great increase in dogbane, a non-palatable annual herb.

The presence of dead shrubs and damage to tree reproduction has already been discussed.

Erosion is believed to be relatively unimportant as an indicator of winter overuse in this area. There are a few open hillsides on south and west exposures where part of the surface soil has been washed away, but in general these areas are small. The most conspicuous evidence of erosion is on the southwest exposure north of Phil Creek, where there is no tree growth over the shrubby vegetation.

Pearce (1937) lists witch-hobble as a key species for indicating the intensity of deer browsing in the Adirondacks. Similarly, we might name willow for the South Fork. However, it would seem better here to judge the degree of use by inspection of the preferred parts of the range, namely the hillsides on south and west exposures. Observations have indicated that damage has progressed from the slopes down to the flats and stream bottoms. Elk take to the bottoms only when driven there by heavy snows or lack of feed on the slopes. Extensive utilization of this lower browse in a moderate winter, therefore, indicates that the forage on the uplands is gone.

### EFFECT OF OVERBROWSED RANGE ON THE ELK

Depletion of the food supply on the winter range has its first effect on the younger elk. They are less able to buck the deep snow in search of food, and for this reason usually follow in the tracks of the older animals, where most of the feed has been taken. As overbrowsing progresses, much of the food still available to the older animals is out of reach of the calves. Preble (1911) reported that in Jackson Hole, Wyoming, during the winter of 1910–11, there was a mortality as high as 90 per cent among the calves in some bands. Thus one of the first effects of overbrowsing may be the loss of the young, upon which perpetuation of the herd depends.

Just what will be the effect of the abnormally large coniferous diet of the elk in the overbrowsed area is not certain. With respect to cattle, Dayton (1931) states, "The terpenes and other oleoresins of conifers are apt to have an irritant effect, and a considerable number of cases of scours and abortion have been attributed to them." Considering the heavy losses in the South Fork during the past five winters, one must conclude that conifers alone do not make an adequate diet for elk. On the winter range the elk have not shown a tendency to move from an area that is overbrowsed to one where feed is plentiful and dozens of them have starved when there was abundant feed a few miles distant. Such has been the case on White River and Cayuse Creek. The latter drainage is only six miles from Basin Creek where feed is abundant. Similar behavior on the part of the elk on the Olympic Peninsula has been observed by Kavanagh (1930). An effort is being made to achieve better distribution through salting of the animals on the Big Prairie District, but the results to date do not warrant definite conclusions.

A greatly increased loss from parasites and diseases is to be expected as a result of the poor condition of the animals resulting from insufficient and improper diet.

It has been noted during the past two years that there has been an increased number of bulls with small, inferior ant-

lers, a condition that has been associated with malnutrition in deer (Leopold, 1936).

## SUMMARY AND CONCLUSIONS

1. There are estimated to be 2,600 head of elk on the Big Prairie District, with a summer range of over 420,000 acres.

2. In winter, because of snow conditions, the area is reduced to not more than 70,000 acres.

3. The vegetation of the winter range is primarily coniferous forest, with an understory of shrubby and herbaceous plants, most of which are palatable to the elk. In the Danaher Creek area, which occupies about one-third of the winter range, there is more grassland, and the forest is interrupted by small patches of grass, making it possible for the elk to subsist largely on herbaceous plants, while in the other two-thirds of the range, their most important food is browse.

4. Part of the grass forage on the range is required by government and recreationist horses.

5. Natural closing-in of the old burns by forest in consequence of fire protection has reduced the carrying capacity, but has not in itself, made the area untenable for elk.

6. Other mammals in the area are a relatively unimportant influence in decreasing the winter food supply. Beavers tend to increase it.

7. There has been a large increase in the herd in recent years, brought about largely by restriction of hunting in the former Spotted Bear Game Preserve, by elimination of mountain lions, and by decreased hunting by Indians.

8. About 20,000 acres of the winter range below the mouth of Young's Creek is now overbrowsed, new growth being almost completely suppressed in mountain maple, chokecherry, serviceberry, aspen, and cottonwood; and greatly reduced in willow and dogwood.

9. Damage to browse first appeared on the hillsides and upper benches, and since 1935 has spread extensively to the flats and stream bottoms.

10. An increased volume of non-palatable shrubs, as buffaloberry, cinquefoil, alder buckthorn, and alder has not yet become evident, but is to be expected in view of the great reduction of the more palatable kinds, mountain maple, chokecherry, serviceberry, willow, and aspen.

11. Damage to conifers, although severe in localities, such as Phil Creek, Big Prairie, and White River, is not as yet evident over a large area. It has been observed only since 1935 but is spreading rapidly, due to the lack of more palatable forage.

12. The succession of spruce on moist sites is being hastened by the elimination of aspen, willow, cottonwood, and even lodgepole pine.

13. Damage to grass has occurred in small areas, due to early spring grazing and trampling, but is retarded through protection by snow in winter.

14. It will be necessary to reduce the number of animals in the overbrowsed area to considerably below the normal carrying capacity if the winter forage is to return to normal. This would involve removal of from 500–600 animals.

15. As a result of overbrowsing there have already been severe losses in the elk herd, particularly among the calves. Unless the animals can subsist on a diet consisting largely of conifers, a severe winter

may wipe out a large part of the herd.

16. It is believed that the stock is being degraded through the effects of insufficient winter food.

17. Winter feeding by man is not feasible because of the extreme inaccessibility of the area.

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# THE PLACE OF BURNING IN MANAGEMENT OF THE GULF COAST WILDLIFE REFUGES

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Fire always has been a factor in the ecology of the Gulf coast marshes. Natural fires have been caused even recently by lightning, and spontaneous combustion has been advanced as another cause. Before the advent of man, natural fires must have been much more severe than at present. The subtropical climate of this region provides a year-round growing season. The resulting growth of marsh vegetation is so luxuriant that an unburned marsh becomes a veritable tinder box within three or four years.

Despite the abundant rainfall of the region, droughts are frequent in late summer. During this same period, squalls accompanied by lighting are almost an everyday occurrence on the coast. Fires started by lightning in recent drought years have lasted for days, even on marsh regularly burned. It is not difficult to visualize the consequences of such fires in former times, before regular marsh burning was practiced. Fed by the accumulated vegetable litter, these natural fires may have raged for weeks at a time.

Man has taken a lesson from these natural fires. Cattlemen, trappers, and operators of hunting clubs burn their marshes regularly. The time and meth- of burning varies with the result desired. The U. S. Fish and Wildlife Service is concerned particularly with waterfowl management on its Gulf Coast refuges. We have conducted an intensive survey of burning programs in operation at the present time, and have engaged in experimental burning in order that the practical knowledge of these private operators might be applied to the extent that is desirable on our areas. While our research has been planned to bring out the beneficial results of burning, at the same time we have studied carefully the possibility of harmful results to wildlife and wildlife habitat. We now feel qualified to give a reliable report on the use of burning on the Gulf Coast refuges, and herewith present our findings.

Marsh fires fall into three fairly distinct types, depending on the condition of the marsh at the time of burning. The most valuable and widely used type is the cover burn, wherein the marsh is fired when there are from three to five inches of standing water present. Such a burn will remove dense vegetative cover, affording birds easier access to food, and facilitating trapping on the muskrat marsh. Cover burns likewise are essential to cattle management on coastal marshes.

A clean cover burn may be had by burning on steady northerly or southeasterly winds every second year. Enough dead vegetation accumulates during the year in which there is no burning to permit a close, clean burn the following year. Clean burns are essential in goose management. A spotty cover burn, on the other hand, is desirable in some marsh types, particularly sawgrass (*Cladium*). Spotty burns result when the marsh is fired on dying or variable winds or in damp weather. Night

fires on diminishing winds give the best results. Spotty burns make open areas in otherwise dense cover. Marsh ducks and shorebirds utilize such burns, while the unburned portions of the marsh provide cover both for ducks and for fur animals as the muskrat, mink, raccoon, and otter.

Cover burns serve five distinct purposes in marsh management. First of all they produce better habitat for geese and ducks. Geese of all species prefer open areas with a minimum of tall vegetation. There were comparatively few geese on the Sabine Refuge in Louisiana during the first two years of its operation, in which time no burning was done. In the fall of 1939, extensive experimental burning attracted approximately a half-million blue and snow geese, in addition to many Canada geese. In the same year burning on the Lacassine refuge, nearby, brought in many Canada and white-fronted geese, and in addition attracted blue and snow geese for the first time since the establishment of the refuge. Cover burning for ducks was practiced the same year on the sawgrass marshes of these refuges, and as a result, thousands of ducks, chiefly mallards and pintails, utilized this otherwise low-value marsh type. Shorebirds, including jacksnipes, likewise were attracted to these burns.

Cover burning accelerates production of food for waterfowl, muskrats, and cattle. Removal of the dense canopy of vegetation gives many important water fowl food plants a chance to mature. On muskrat marshes, the growth of three-square (*Scirpus olneyi*), an important food for both muskrats and geese, is accelerated with removal by fire of dense wire grass (*Spartina patens*). Cover burns on the higher salt marshes aid both cattle and geese as they are followed by growth of succulent vegetation. Within one or two weeks after a fire, the new green shoots of wire grass and salt grass (*Distichlis*) are eagerly sought by all species of geese.

The third function of the cover burn is to increase the availability of food. Many of the good waterfowl food plants in the south produce such a rank growth that birds are unable to get to the seeds and rhizomes. It is virtually impossible for ducks to feed on sawgrass seeds until the dense tangle of marsh vegetation is burned off.

Cover burns, when handled properly, are a practical means of fire protection in the marsh. Marsh lands are in continual danger from summer fires set by lightning or by alligator hunters. Properly burned marsh is not nearly so susceptible to such fires as that which is unburned. Cover burns also greatly facilitate trapping operations. Proper trapping of muskrats in Louisiana is essential to the profitable handling of marsh land. It is impossible to properly trap unburned marsh, and the resulting unchecked increase of muskrats often will lead to depletion of food and damage to the marsh floor.

Cover burns do not affect the structure of the marsh, since they do not reach the basal parts of perennial plants which are protected by standing water. In times of drought, however, it is possible to alter the vegetation of certain marsh types by fire. Root burns or deep peat burns will result from dry fires, depending on the depth to which the water table has dropped below the surface of the soil.

Root burns are characteristic of the

peaty marsh types, including wire grass, "Paille-fine" (*Panicum*), and sawgrass. These marsh types, if left unburned for several years, eventually form an impenetrable jungle of vegetation. Plant litter accumulates to form a deep mulch on the marsh floor. The climax plants of these respective marsh types strike new roots into this litter, abandoning their former root horizons. What happens, in effect, is that these plants move out of the soil proper into the top litter. A marsh in this condition is particularly susceptible to root burns in times of drought. At such times a fire will sweep through the dry litter on the marsh floor, destroying the roots that have emerged from the soil. Even the older and deeper root systems may be affected. Dry fires, fed by the accumulated litter of several growing seasons, become so hot that they actually cook the rhizomes of plants several inches below the soil surface.

Root burns kill off climax vegetation, and allow plants of lower succession groups to reappear in the marsh. Thus in sawgrass marsh, the dense climax of this dominant plant is removed, allowing many desirable food-plants, including spikerush (*Eleocharis*), and waterlily (*Castalia*), to grow.

In times of extreme drought, fires not only destroy existing vegetation, but may burn out marsh peat down to the clay subsoil. Such fires known as deep peat burns occurred in the drought year of 1924. Fires in late summer of that year burned out many square miles of peat in the coastal marshes of Louisiana and Texas. In fact a large part of the best waterfowl habitat in this region is the direct result of deep burns. Many of these areas still are called "burns" by Louisiana trappers, even though some have become completely overgrown again.

Root burns and peat burns serve both to produce waterfowl foods and to create habitat for ducks. The shallow marsh swales left by root burns are preferred by mallards, pintails, and teals. Spikerush, wild millet (*Echinochloa*), and many other food plants occur in such areas. Deep burns are used by diving ducks, as the ringneck and scaup, and serve as resting ponds for the marsh ducks. Pools resulting from deep burns produce waterlily, watershield (*Brasenia*), wigeongrass (*Ruppia*) and other aquatic waterfowl foods.

Under proper management, cover burns are not in the least destructive to wildlife, provided there is sufficient water on the marsh at the time of burning. Fur animals are protected by the water and by lodges in the case of muskrats. Deer lose no time in placing a bayou or other natural firebreak between themselves and the fire. Waterfowl and other marsh birds leave during the fire, but often return to the fresh burn before rain has had a chance to dampen the ash. Flocks of gulls, blackbirds, swallows, and other birds are in regular attendance at every marsh fire. Often they may be seen in the very thickest part of the smoke, catching insects driven out by the fire.

Any dry burn, on the other hand may be quite destructive to wildlife, Rabbits and fur animals, in fact all marsh wildlife except birds, may be exposed to destruction. However, climax marsh in which such burns are most likely to occur usually contains little wildlife of any kind. Furthermore, in drought years fur animals will be found con-

centrated around water areas. The loss of wildlife remaining in dry climax marsh is insignificant compared to that which is benefited by the habitat improvement following dry burns. An experimental dry burn on the Sabine refuge demonstrated the resourcefulness of animals in the face of such fires. Raccoons, minks, otters, and rabbits took shelter in alligator holes until the fire had passed, and subsequent sign showed that with the exception of rabbits, the larger part of the wildlife escaped unscathed.

## SUMMARY

Marsh fires fall into three classes: cover burns (which may be either clean or spotty), root burns, and deep peat burns. Burning may serve one or more of the following functions: improvement of habitat, promotion of food production, increasing availability of food, protection from fire, and facilitating trapping. Cover burning, properly done, does not destroy valuable wildlife species, and the inevitable loss of wildlife in root burns or peat burns is more than offset by improvement of habitat and later gains in the wildlife population.

Our findings clearly show that burning is a most efficient and practical tool in management of the Gulf Coast marsh refuges. At the same time we wish to point out that at present these findings are recommended for use only on the Gulf Coast, and before being adopted in other parts of the country, should be tried experimentally.

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# OBSERVATIONS ON THE HOMING BEHAVIOR OF THE GRAY SQUIRREL (SCIURUS CAROLINENSIS)

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Very little is known about the homing behavior or territory of many common mammals, including the gray squirrel (*Sciurus carolinensis*). Hamilton (4) stated that homing behavior is apparently well developed in most of our native mammals and cites examples of deer mice (*Peromyscus*) returning from distances up to two miles, following their being trapped and liberated at various removes from the home site. Hamilton also has taken red squirrels (*Sciurus hudsonicus*) and eastern chipmunks (*Tamias striatus*) from their home territory and found that they soon returned from distances of slightly more than a mile, and 700 paces, respectively.

Territorial boundaries of the pine squirrel (*Sciurus fremonti*) in Colorado and the Douglas squirrel (*Sciurus douglasii*) in Oregon have been studied by Gordon (3). The former species guards an acre or two; the latter has a territory of not more than half an acre that is defended from other squirrels that enter for food. The fox squirrel (*Sciurus niger*) in Ohio is reported to be normally sedentary with an average cruising radius of 149 yards, and a maximum of 375 yards (1). The annual cruising radius of the gray squirrel has not been well defined, but it is generally accepted to be less than half a mile, particularly in winter when some territories have a radius of only a few hundred feet.

An occasion to study homing behavior as distinct from normal territorial movements occurred when a grain shed on the property of the University of Connecticut, at Storrs, was broken into by gray squirrels in 1938. The squirrels fed on corn and mixed grains more or less continually throughout the critical winter months until the spring of 1940. During this time the grain supply became an integral part of their territories so that by the winter of 1939–40 the shed was visited daily by at least one of the animals and occasionally three squirrels were discovered in the building at one time.

Beginning October 15, 1939, live trapping was conducted in the shed. It was continued, except for two brief interruptions, up to the last week in March, 1940. During this time nine different males and six different females were caught. Of these, all but one male were toe clipped, placed in sacks, carried by auto to picked locations, and released. The points of release varied from 3,000 to 20,000 feet from the point of capture, along three general lines running in westerly, northeasterly, and southerly directions. Special care was taken to prevent the animals from seeing the country between the point of capture and that of release. When available, two animals were released at each point on different days.

The westerly series was completed first. The land along this line of release was characterized by almost continuous forest cover composed largely of immature oak, hickory, and maple, interspersed with a few small coniferous plantations, an occasional field or re-

verting pasture, and a few little-traveled roads. The weather during these releases was marked by long continuous periods of cold with comparatively little snow. The northeasterly and southerly series were started later in the study during periods of unusual snowfalls. Forest cover in those directions was essentially the same as noted in connection with the westerly series, but was more interspersed with open fields. No large, continuous bodies of water crossed any of the routes between the points of release and the point of recapture.

number of retrapped individuals is six out of 15. However, three previously untrapped animals released during the middle and latter part of February may not have had time to return. It is interesting to note that only one female was retrapped during the entire experiment. This may indicate greater activity among the males such as has been noted for the cottontail rabbit (2) and mink (5).

The time required for the squirrels to return can be expressed only in general terms since the time between their return and their retrapping is unknown.

TABLE 1

RECORDS OF RELEASES, DISTANCES CARRIED, AND DATES RECAPTURED BY SEXES

| *Animal number* | *Date caught and released* | *Sex* | *Distance to point of release* | *Date recaptured* |
|---|---|---|---|---|
| | | SERIES I (WESTERLY) | | |
| 2 | October 25 | ♀ | 9,000 ft. | |
| 3 | October 30 | ♀ | 8,200 ft. | |
| 1 | (retrapped from series 2) | | | |
| | November 6 | ♂ | 6,800 ft. | December 6 |
| 4 | November 6 | ♂ | 8,200 ft. | December 4 |
| 5 | November 6 | ♂ | 4,800 ft. | December 6 |
| 6 | November 6 | ♂ | 3,000 ft. | November 16 |
| 7 | November 7 | ♂ | 3,000 ft. | December 11 |
| 9 | November 9 | ♀ | 3,000 ft. | |
| 6 | November 16 | ♂ | 6,800 ft. | |
| 10 | November 29 | ♀ | 3,000 ft. | |
| 4 | December 4 | ♂ | 12,000 ft. | |
| 6 | December 11 | ♂ | 14,800 ft. | January 6 |
| 7 | December 11 | ♂ | 14,800 ft. | January 27 |
| | | SERIES II (NORTHEASTERLY) | | |
| 1 | October 15 | ♂ | 3,400 ft. | November 5 |
| 8 | November 7 | ♂ | 3,400 ft. | January 6 |
| 11 | December 6 | ♂ | 5,600 ft. | January 2 |
| 12 | December 6 | ♀ | 3,400 ft. | |
| 1 | December 6 | ♂ | 9,200 ft. | |
| 11 | January 2 | ♂ | 3,400 ft. | |
| 13 | January 10 | ♀ | 5,600 ft. | March 10 |
| 7 | January 27 | ♂ | 20,000 ft. | |
| | | SERIES III (SOUTHERLY) | | |
| 5 | January 6 | ♂ | 16,900 ft. | |
| 14 | January 18 | ♂ | 6,850 ft. | |
| 15 | February 2 | ♂ | 6,850 ft. | |

Squirrels numbers 1, 5 and 7 were trapped three times and numbers 11, 4 and 6 were trapped twice, so that the

It appeared that very few animals escaped capture because of trap shyness even after being caught once. Trap-

ping technic was varied considerably to maintain as high efficiency as possible.

The maximum distance returned was 14,800 feet. This distance was covered by two different squirrels, one of which returned to the trap in less than four weeks. This represented not only the maximum distance, but also the minimum time per unit of distance traveled. Both of the animals completing this trip were taken farther away the next time but neither was again recaptured.

The longest successful returns were from the westerly series of tests, which were chiefly with the first animals caught. It is thought that these animals showed increased homing tendencies for at least two reasons. These squirrels were the original inhabitants of the area surrounding the grain shed prior to trapping. As such they were probably more familiar with the territory than those trapped later, which may have represented infiltrations into the territory freed of the previously trapped animals. Also, increased snow depths hindered travel later in the winter and may have made conditions too difficult for returns.

## SUMMARY AND CONCLUSIONS

Of 15 gray squirrels trapped from a single feeding location in Storrs, Connecticut, and released along various lines through nearly continuous forest cover, six were recaptured at the original site. Of these, three returned twice. The maximum distance from which squirrels returned was 14,800 feet. This occurred once in less than four weeks, representing the fastest time per unit distance traveled. The largest return was among the first group of squirrels trapped from the area prior to December 11, 1939. This was thought to be due to greater familiarity with the section by the squirrels originally inhabiting territories nearby, and to a lack of snow which during the latter part of the winter served to restrain movement of the animals. Only one female was retrapped, possibly because of the naturally lesser activity of this sex, showed by small mammals.

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# THE SPAWNING HABITS OF CUTTHROAT AND EASTERN BROOK TROUTS

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During the summer of 1940 a series of experiments on natural spawning of trout was started at the Convict Creek Experiment Station in California.[1]

Wild trout were trapped during their spawning migrations and transferred to Convict Creek, where they were induced to spawn in controlled stream sections. These consist of old side channels of Convict Creek which may be controlled with flash-board gates and screens. Most of them are about 4 to 6 feet wide, with an occasional pool up to 22 feet wide, and the flow in each was about 2½ cubic feet per second. Each side channel was designated by a letter, and the sections were numbered from the upper end down. Thus, Section E2 is the second section in channel E, and E3 is the next one downstream.

Cutthroat trout (*Salmo henshawi*) and eastern brook trout (*Salvelinus fontinalis*) were used in these experiments.

The spawning habits of both species are described in some detail because very little is known about this feature of the life history of salmonids and to date there does not seem to be any published account of the difference between the habits of these two species. In 1824, a Mr. Halliday[2] published a reasonably accurate account of the Atlantic salmon's general method of depositing and covering eggs and Sir Francis Day (1887) seems to have understood the matter, but most of the investigators who came after these men have misunderstood the process entirely. Their misinterpretations were the foundation of most of the old ideas on the inefficiency of natural fertilization. The description by Needham and Taft (1934) is the first published account clearly describing the actual spawning act of any salmonid.

[1] The Convict Creek Experiment Station is operated by the U. S. Fish & Wildlife Service, with the cooperation of the U. S. Forest Service and the California Division of Fish and Game. It is on the eastern slope of the Sierra Nevada, north of Bishop, California. The experiments described were carried out at the suggestion of Dr. Paul R. Needham, and the author wishes to thank him for much helpful advice in planning the work.

## Terminology

*Redd.*—"The total area excavated by a fish in any one portion of stream bed and in which ova have been deposited" (Hobbs 1937). Synonymous with nest. Usually situated at the lower end of a pool, where the current is rapid enough to carry away disturbed silt and sand. So far as known, a redd always consists of a group of filled-in egg pits.

*Egg pit.*—The pit or pocket in the gravel excavated by the female to receive one batch of eggs, following Hobbs' (1937) conception.

## Cutthroat Trout

On May 4, 1940, twelve wild cutthroat trout were supplied by the California Division of Fish and Game from their egg-taking station at Heenan

[2] Quoted by Sir Francis Day (1887) p. 81.

Lake, Alpine County, California. One male died en route to Convict Creek but the others stood the 120-mile trip well and were lively when released. All of the trout were "green" according to hatchery standards, that is the bodies of both sexes were still so hard and firm that the eggs and milt could not be squeezed out by hand. The fish were all about the same size, ranging from 18 to 21¾ inches, total length.

*Distribution of Fish and Spawning Periods.*—Three male and three female cutthroats were placed in experimental stream section E3 at 10:30 p.m. on May 4, 1940, immediately upon arrival from Heenan Lake. This number was put there to increase the chances that at least one pair would spawn. Of these, one female started to spawn on the morning of May 7th, about 35 hours after liberation. She continued to spawn for two nights and two and a fraction days, evidently laying her last eggs on May 9th. Another female spawned on the same gravel area starting on May 9th and apparently finishing, after numerous interruptions, before sunrise on May 12th. Thus the spawning periods of the two females overlapped a part of a day and their redds occupied the same area. The third female was taken out on May 12th and liberated in the main stream to avoid further overlapping of redds. She was still too hard to be stripped by hand.

Only one of the three males in E3 spawned, and he spawned with both females. One of the others began to show a little interest just before all spawning activities ceased, but the first male kept him away. He was transferred to Section E2, above, where there were not enough males, after the two females in E3 had finished egg laying. The third male showed no interest in the spawning.

Two females and only one male were placed in section E2 on May 6th. One female started digging on May 9th, and the other one was first seen digging on May 13th below the first redd. The lone male was trying to court both of them. On that day, as mentioned above, a male from E3 was added to E2 and thereafter the fish paired off and all spawned. One pair was placed in C7 on May 6th and they were first seen digging on May 12th. Spawning observations ended May 15th.

*Number of Eggs Left in Females.*—After the females had spawned they were caught, measured, and the eggs remaining in them were counted. Those in E3 were taken out May 15th. The first female to spawn had three eggs left; the second contained 109 eggs. As will be explained, this female was interrupted often during the spawning period, and she probably had not finished when she was killed. The females in E2 were taken out a month later, June 14th. One had three, the other four eggs. The female in C7 was found dead, having been trapped on the horizontal screen, on May 23rd. She contained only three eggs.

The males were removed from the sections and liberated at the time the females were examined.

*Recognition.*—It was very easy to distinguish the sexes because of the large head and jaws of the male. This characteristic may be seen in the Plates. Furthermore, after watching these few fish steadily for several hours it became very easy to distinguish individuals by the general coloration and by the ar-

rangement of the spots on the head.

*Methods.*—Before the trout were liberated, blinds were placed near the stream so that observations and photographs could be taken from within four or five feet of the fish without disturbing them. A plank was floated across the stream to flatten out bubbles and ripples. This made photography possible, for pictures taken through surface ripples were worthless. Perhaps the most important item was patience. The cutthroat trout were observed almost constantly from sunrise to sunset for 8 days and sporadically for a few days longer. A watch was used to obtain approximate time and duration of various actions but no attempt was made at timing to seconds.

Experimental section E3 was not originally very suitable for spawning but it had been improved only a few days before the cutthroats were liberated by shoveling in gravel from the main stream. When the trout were in the section it was found that the spawning area in E3 was so shallow that the backs of the large cutthroat trout would break water. This might not have prevented them from spawning but it would have made photography impossible so the pool was deepened by adding gravel at the lower end and by constricting it with sods. It is rather interesting that this improvement and even changes made after the trout were present did not prevent them from accepting it for spawning the next day.

*Spawning Activities.*—Section E3 was watched continuously, and all observations refer to fish in that section.

The egg pits were dug at the lower end of the pool, just above a riffle. All digging was done by the female. She would turn on one side, press her tail down flat against the gravel, and flap it vigorously up and down about five to eight times. In so doing she would propel herself forward and upward, often breaking water and making a rapid forceful sort of "chug-chug" noise. The pectoral fins were held out rigidly to help check the forward movement. The mouth was slightly open and the eye balls rolled so that the "whites" showed, evidently due to muscular exertion. The digging motion would start with the tail in the pit and usually would carry the fish about two feet upstream, or occasionally diagonally out toward one bank or the other. The female would dig in this way every few minutes with occasional interruptions of ten or fifteen minutes, until the pit was deep and clean enough for egg laying. It usually took from two to four hours to prepare each egg pit. Once, when two females were attempting to use the same area, it took one of them seven hours.

The male was very attentive while the female was working but he did not do anything to help. Courting and driving away other fish seemed to be his only activities. If any of the small wild fishes in the section, or one of the other big cutthroats approached the nest the male would chase them away, often with gaping jaws. The two other big males in the section did not appear to be interested in the spawning procedure and always retired without a fight.

The male stayed beside the female or a little downstream, sometimes on one side, sometimes on the other; and frequently he would nudge her or swim up against her and quiver. Usually his snout was about opposite her dorsal fin, but sometimes he would come up even

with her. Quivering seems to be the principal courting act among trouts for it has been observed by several authors. It would sometimes occur several times between digging acts by the female and on one occasion it was observed three times in two minutes. There was no regularity or alternation of digging and courting. When the female was frightened away, she would usually dart into the pool above and the male would follow, quiver beside her, and then return to his position over the redd. If she did not follow him immediately, he would often go up and quiver beside her again, apparently trying to lead her back.

As digging progressed and the egg pit deepened, the male became more and more excited, though the female seemed to plod along at about the same rate. He would quiver against her more and more often, change sides frequently, and often hang so close to the female that she would jostle him when digging. Once the male was almost thrown up out of the water when he tried to change sides just as she started to dig. When the male changed sides he often took the shortest route by sliding over the female's caudal peduncle but this appeared to be merely from excitement and indecision as to which side was better, not a courting act.

When the pit began to take shape, the female frequently settled down into it, feeling around the stones with her anal fin as though testing the shape or cleanness of the pit. Needham and Taft (1934) mentioned a similar "testing" action.

The completed egg pit was a depression in the gravel 4 or 5 inches deep and about a foot in diameter. It was always shorter than the fish making it, so that the female had to curve her body to press her anal fin against the gravel. The bottom of the pit, where the eggs are deposited, was not a simple hole in the gravel such as one might make with a shovel, but was washed clean of all silt, sand, and even fine gravel, leaving only coarse clean stones with wide spaces between. A very similar hole can be made by rapid hand movements over gravel, without actually picking up or pushing any of the stones. When eyed eggs are artificially planted, greater returns might be obtained if they are placed in an egg pocket cleansed in this way.

After testing the pit many times, the female finally settled down into it so that her anal fin pressed into the crevices between the stones and both her head and tail were curved slightly upward. Instantly the attentive male was beside her, in the same position, and then both fishes opened their mouths, became rigid, and both eggs and milt could be seen flowing into the pit. Both fishes quivered slightly during the spawning act. The vibrations were not as obvious as the male's courting vibrations, they appeared more like "unintentional" quivering from straining muscles. The spawning act was seen seven times, from a distance of four to six feet, and in almost every case milt could be seen clearly as well as the bright orange eggs as they sank to the bottom of the pit and lodged in the wide clean crevices between the stones. Some, which did not fall into the crevices adhered to the tops or even the sides of stones, indicating how the adhesive quality of newly-laid salmonid eggs helps to keep them from being washed away. In all observa-

tions on the spawning acts and in careful scrutiny of the gravel and screen below, only eight eggs were found to have been washed down stream.

The milt diffused through the water much as does a small puff of steam in the air. Plate 32 shows how it spread sideways to the far side of the female and actually forward of the male's vent, thus giving ample opportunity for fertilization of all the eggs in the pocket. The milt cloud held its position for a moment and then gradually dispersed. Though the stream was flowing rather rapidly over the redd, the pit had been made just deep enough to form an eddy of quiet water, in which the milt spread both sideways and upstream. The presence of an eddy in the egg pocket was observed by Hobbs (1937), who surmised that it would have the effect actually observed in this case. Cramer (1940) mentions a similar cloud of milt, but he did not see the eggs.

Immediately after the eggs were laid, both fishes left the pit and for 15 or 20 seconds the eggs were clearly exposed. Then the female moved to the upstream edge of the pit and started to cover the eggs. This process was exactly like the digging, except that she worked at the upstream edge of the pit and the gravel was washed down over the eggs by the current. The first or second dig would usually cover most of the eggs but it always took several tries during about two minutes to cover all of them. She continued to work in this way until the pit had been completely filled and the gravel well-mounded over the eggs. The mound was higher than the original stream bed, and apparently the eggs were covered by 6 or 8 inches of gravel. It took about 40 minutes to an hour or more for each mound to be completed, depending upon interruptions.

By this time, the female had dug a new pit just upstream. Sometimes she continued working at this new pit, preparing it for another batch of eggs. This seems to be a common procedure

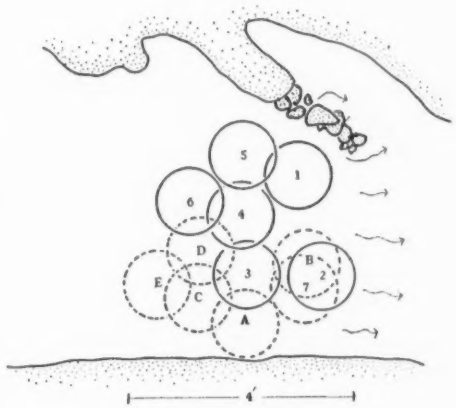


Fig. 1. Diagram of egg pits. Solid circles are pits made by the first female, numbered in order of construction. Dotted circles are pits made by the second female, lettered in order of construction. The dotted circle with the number seven was dug by second female but the first one spawned in it. The eggs themselves occupied areas roughly the size of the numbers and letters.

(Needham and Taft, 1934; Hobbs, 1937; and Schultz, 1937) and it is certainly an excellent labor saver. However, in the stream section here concerned the female did not always do this. More often she started a new pit at one side of the mound just completed or even at some distance. Figure 1 shows the order of construction and arrangement of the egg pits.

The male stayed nearby and guarded the redd while the eggs were being covered, but he was not nearly as attentive as just before the spawning act.

The complete egg-laying cycle, from one spawning act to the next, took four hours and thirty-four minutes on one occasion and five hours and twenty-five minutes on another. These were the only times when one female spawned twice during the daylight hours of one day. From the appearance of the gravel, spawning obviously continued at night but apparently at no faster rate.

Often, just before the actual spawning act, both sexes would go through all the motions of spawning yet no eggs would be dropped. The positions, the open mouths, and the quivering would all be the same, and sometimes a very small faint cloud of milt could be seen but no eggs were laid. It looked as though the female were trying to squeeze out eggs but did not succeed. Conditions for observation were so nearly perfect that any eggs would certainly have been seen. After this action, which may be called a "spawning attempt," the female never made any move to fill in the pit; in fact she would often dig once or twice more in the center of it. This was strikingly different from her actions after successful spawning. These "attempts" became more and more frequent as egg laying progressed. Once a female made ten of them before achieving success. This was the first female after she had been watched for two and a half days. She had spawned four times by day, and from the appearance of the gravel, probably at least two or three times at night. When she did spawn this time, only about 10 eggs were dropped, as though she were squeezing out the last few. This may well have been the case because, so far as could be seen, this was her last spawning act.

*Night Spawning.*—Changes in the mounds of gravel during the night, and the presence of the fish over the nest until scared away gave evidence of night spawning. Needham and Taft (1934), Greeley (1932), and others, report similar evidence of night activity. The fish were frightened by all lights, including dull red. Even if a light was left beside the stream for an hour fish would not return to the redd.

*Egg Predation.*—There was a natural population of wild fishes in the experimental stream sections in which these observations were made. Out of this wild population there was one cutthroat or possibly a rainbow-cutthroat hybrid about six inches long, that took part in the spawning activities. Unfortunately this fish could not be caught for examination, but from its actions it was obviously a sexually mature male. He put in an appearance as soon as the big cutthroat started spawning and most of the time he held a position below the egg pit, this being the position farthest from the jaws of the big male. This fish went through all courting activities that the large one did and evidently joined in the spawning act. He would nudge the female, and he would swim up to her, on the side away from the big male, and quiver. He usually did this against her caudal peduncle, with his head well back of her dorsal fin. Then when the big pair actually spawned or when they made a spawning attempt, he would dart up against the female, on the side away from the big male, and crowd in against her in the region of the vent.

Cutthroat trout at moment of spawning. The white "cloud" of milt is filling the pit and has spread beyond the female (nearer the camera).

Female cutthroat trout with tail flat against the gravel at start of digging action. She is covering eggs, which are exposed just back of her tail, beside the male. This picture was taken one minute after that shown in Plate 32.

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So far as could be seen this small male did not eat any of the eggs, even though he had ample opportunity to do so. Immediately after the spawning act he would take up his position at the downstream edge of the pit and completely ignore the eggs exposed a few inches in front of him.

It has been demonstrated from stomach samples (Greeley, 1932; White, 1930) that trout as well as other fishes will eat trout eggs, but most of those eaten are probably those washed downstream and, therefore, waste eggs. The significance of the present observations is that, in this case, the small fish was plainly interested in spawning and he did not avail himself of the ample opportunities to pick up newly-laid eggs. In a photograph not reproduced herewith the head is shown well forward of the female's vent, bringing his vent about opposite hers. This certainly is not the position he would take if he were trying to grab the eggs as they dropped into the pocket, but it is the normal position for fertilizing the eggs. Furthermore, of all the wild fishes in the section, only this one was paying any attention to the spawning activities. If there were an egg feast to be had, surely some of the brown trout present would have attempted to share it.

*Guarding Completed Redd.*—As mentioned before, two females spawned with one male in section E3, not counting the small precocious male. One female started to spawn before the other had finished, and their redds occupied the same area.

When the second female first started to show interest in spawning, she came up to the spawning area and tried to dig several times during the morning, but each time the male drove her away. Sometimes he would "escort" her away, much as Schultz (1937) says male salmon do with each other; at other times he attacked fiercely with his jaws wide open. Once after he had escorted her away they came back together and both hung over the redd quietly. In spite of all these interruptions, the second female finally succeeded in getting a pit well excavated, but only to have the first female, which had been quiet all morning, come back, finish her rival's pit, and spawn in it herself. This was the spawning act preceded by ten attempts as mentioned above. The male accepted her as soon as she returned.

Though this appeared to be the last time that the first female spawned, she occasionally returned and threw more gravel over the redd during the following two days. When she returned the male often nudged her and then immediately turned and drove off the second female even though he had recently spawned with her. Sometimes he switched from one female to the other, and once the first female made a pass at him as though reprimanding him. He drove off the second female almost every time the first appeared, though on the second day after the first had finished spawning he drove her away once.

After the first female had finished spawning she drove off the other one several times, often as fiercely as a male. She had never shown any inclination to guard the nest while she was spawning, though this may have been merely due to the absence of other spawning females.

The guarding action on the part of the first female as well as the male's somewhat confused preference for her

may represent a rudimentary nest-guarding habit. Such behavior would tend to discourage a female from tearing up a completed redd, provided unguarded spawning gravel were available nearby.

After both females had finished spawning, there was very little activity and most of the time the male and both females stayed quietly in the pool. Once both females were seen side by side over the redd but paying no attention to each other.

*Damage to Eggs by Overlapping of Redds.*—The second female apparently did not disturb many of the previously buried eggs. During all of the digging and spawning activities, as noted above, only eight eggs were found to have drifted down below the redds, and of these only four drifted down when the second female was digging.

The clusters of eggs are in relatively small and compact pockets and it would be possible for a newer egg pit to overlap another without disturbing the eggs in the first one, provided the centers did not coincide. In this case the pits did over-lap, but apparently not enough to disturb the eggs. Figure 1 is a sketch of the approximate arrangement of the egg pits in the redds made by the two females. Trout undoubtedly destroy eggs of their own kind, especially when spawning grounds are crowded, but the present observations indicate that the proportion of eggs destroyed in this way is probably small.

### EASTERN BROOK TROUT

Eastern brook trout were observed spawning at Convict Creek between November 14th and 27th, 1940. The California Division of Fish and Game provided six pairs of ripe spawners from their egg-taking station at Little Walker Lake, Mono Co., Calif. Eggs are taken here from a wild population of trout, individuals of which are trapped on their spawning run out of the lake. All of the fish were relatively ripe, due to the lateness of the season. They arrived at Convict Creek November 13th and were placed in live cars.

Two pairs of brook trout were released in section C3–4 and two in section E2 on November 14. Another pair was added to each section the next morning. Digging activities were seen in C3–4 from November 15th to 18th, and in E2 from the 16th to the 23rd

The fish were removed from C3–4 on November 26th. The three females had 1, 6, and 40 eggs, respectively, left in them, apparently all but the last individual having completed spawning. Section E2 was drained and the fish recovered on November 27th. The three females had 4, 98, and 157 eggs left in their bodies, which indicated that only one had spawned completely. Much of the activity took place during the long winter hours of darkness and consequently the complete day to day history of the activities of individual fish could not be followed as accurately as it was with the cutthroat trout. Nevertheless it was easy to recognize individual fish and distinguish the sexes. Characteristic shades of coloration and scars served to identify individuals, and the protruding genital papilla and more dull ventral coloration distinguished the females. There was no marked difference in the size of the head or jaws. All of the fish were about the same size, the range being $8\frac{7}{8}$ inches to $9\frac{3}{4}$ inches, total length.

*Spawning Activities.*—The brook trout females dug pits in exactly the same way that the cutthroat did, and likewise the males took no part in the digging. The digging action, the position of the fins and even the open mouth and rolled eyes were characteristic. The dimensions of the pit were about the same in proportion to the length of the fish.

A similar quivering courtship act was observed on the part of the male, though it seemed to be of shorter duration in the brook trout. Usually the male held a position slightly below the female, from where he darted up beside her and quivered while gliding past, without actually stopping. Frequently he did not even touch her, but passed about an inch away, quivering as he went. The quiver and an occasional gentle nudge were the only courting acts seen.

When the fish were frightened away from the pit or departed without apparent reason, the male usually returned first. If the female did not return soon he would go up to her and quiver, apparently to coax her back. Sometimes another female came over the general area first and then the male started to court her, but when the owner of the pit returned the male always went back to her.

Both males and females guarded the egg pit. If a strange male approached, the male owner might ignore him for a while but sooner or later would drive the intruder away. Usually the male in possession just swam toward the intruder, which retired without a fight, but sometimes the owner charged with jaws open. The owner always started the fights, while the intruder always seemed to be trying to sneak in close to the female unnoticed.

When the intruder was a male, the female paid no attention to the proceedings, but if a strange female approached, she immediately assumed the "on guard" position, with the pectoral fins held stiffly out and forward, the dorsal fin often slightly elevated. Several times she charged an intruding female with her jaws open, but usually the intruder departed peaceably. If the intruding female did not retire at once, both would stiffen into the "on guard" position. Then, parallel and even with each other, both would slowly swim up to the pool above, without relaxing their pectoral fins. After reaching the pool above, the owner of the nest would leave the intruder and sooner or later return alone, though there did not appear to be anything but prior right of possession to decide the issue. Plate 35, upper picture illustrates the start of one of these actions. It was very much like the escorting that Schultz (1937) describes for the male little red fish, or what Reighard (1908) called "deferred combat" in the creek chub, but in each case the participants were females.

The female owner of a nest often behaved pugnaciously and went out of her way to attack other females. On several occasions she suddenly left the egg pit and darted toward a female lying quietly in the pool above, eight or ten feet away. The male also at times drove away an intruding female, and sometimes joined the female owner in chasing an intruding female; usually, however, he did not appear to object to the presence of another female. He was more likely to nudge an intruding female or quiver beside her, especially if the rightful owner was away temporarily. A female was never seen to attack a male.

Brook trout spawned in exactly the same way as the cutthroat. The act was observed three times, and at two of these, the eggs could be seen flowing into the pit and at the third, the eggs were noted immediately afterwards. A small white cloud of milt was seen in each case. Most of the eggs settled into the carefully cleaned crevices between the larger stones at the bottom, and a few clung to stones farther up, but none was seen to be washed down stream. About 60 eggs were laid at one time and about 15 at another.

Two males participated in one of the spawning acts. The intruder had been hanging below the pit for some time and had occasionally quivered beside the female in spite of the other male's defense. Then, just as the rightful owners of the pit went into the spawning act, the intruder darted up to the opposite side of the female and assumed the same position. Both males ejected milt.

Two false spawning acts were seen. As with the cutthroat, the action appeared just like spawning and milt was discharged but no eggs were deposited. Immediately afterward the female cleaned out the bottom of the pit, instead of filling it in with gravel as she did when eggs were deposited.

*Covering the Eggs.*—Immediately after laying the eggs, the female started to cover them with gravel, but by a method entirely different from the cutthroat, steelhead, or salmon. Instead of going to the upstream edge of the pit and digging with her tail, she backed down over the mound which is always formed at the downstream edge of the pit and started sweeping pebbles forward with her anal fin. The anal fin was held down against the stones and then by a twisting movement of the body and a slight push with the tail it was scraped, point foremost diagonally across and upstream. The movement was a sweeping one and the fin did not actually dig into the gravel. Many times not a single pebble was disturbed by the movement, but as the female rhythmically swept the gravel diagonally from first one side and then the other, she gradually moved pebbles forward and over the eggs. She did not disturb any of the eggs while doing this. Plate 35 shows the female in the midst of a sweeping movement. One egg is exposed on top of a stone and a small cluster of four or five may be seen between the stones under her body.

So far as speed of accomplishment and the amount of effort involved are concerned, this method of covering the eggs is very inefficient, for, in the two cases when daylight permitted complete observations, it took the female thirty-one and forty-two minutes to cover all the eggs. However, this method may be very beneficial biologically, for the end result was to cover the eggs with clean pebbles, rolled individually and gently over them. The pile of stones that is formed down stream from a pit during the digging process is relatively clean because the finer silt and sand has been washed away and for this reason very little fine material could be swept over the eggs. Hence there would be a good flow of water through the gravel and over the eggs.

The sweeping movement was continued for fifty-two and thirty-seven minutes, respectively, after all the eggs were out of sight. Then the females changed their method by moving upstream, turning on one side, and digging

Cutthroat trout separating immediately after spawning. Eggs are visible in circle. This is the same male shown in Plates 32 and 33, but another female.

*Upper*—Eastern brook trout female escorting another female away from pit. Note extended pectorals.

*Middle*—Eastern brook trout female (lower fish) sweeping gravel forward over eggs with anal fin. Left arrow points to one egg and the right to a cluster of four or five. Other eggs have settled between stones.

*Lower*—Eastern brook trout female, showing characteristic twisting while sweeping pebbles forward over eggs with anal fin.

with the tail. Both methods were used a few times, but after a while the characteristic digging motion alone was employed. The females dug upstream from the egg pocket and occasionally on each side, so that gravel was gradually thrown up into a mound over the eggs and a semi-circular depression was formed around its upper edge. In each case it took more than four hours to form a fair-sized mound and the females threw stones on it occasionally for a much longer period. The completed mounds were roughly oval, about ten by seven or eight inches across and two or three inches above the surrounding gravel. The outlines of the mounds became more and more indistinct as the gravel area was worked over by different females, but apparently the females never dug directly into a completed mound.

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# BRIEF CONTRIBUTIONS

*A Note on Deer Mortality and Reproduction.*—During the latter half of February 1941, in the vicinity of the Village of Wells, Vermont, there were several reports of dogs chasing deer. These reports were confirmed by signs observed in the snow.

On February 25, 1941, several men on their way to work in the woods noticed a dead deer embedded in the ice on the edge of Wells Brook. Robert Lucia estimated that the doe would have weighed about 150 pounds, rough-dressed. He, at first glance, thought her to be an old, barren individual, but upon noticing signs of pregnancy, he opened the frozen carcass and removed three young about the size of large rats. The young were well developed, but hairless. Approximately one-quarter of the deer had been eaten by dogs at this date and it seemed as though the animal had been dead for about a week.

Apparently the doe was unable to escape from three dogs. In attempting to spring across the partially frozen stream, a distance of 20 feet, she slipped on the far edge and broke through the ice. She could not get loose and the dogs probably killed her with ease.

On March 3, 1941, most of the carcass had been eaten by dogs and wild carnivores.—WILLIAM H. MEYER, Soil Conservation Service, Poultney, Vermont.

*A Long Straight-log Dam.*—In a previous issue of this Journal (4: 437) I described the construction and functioning of the straight-log dam and stated that it was well adapted for use on small streams, with the intended implication that it was not suited to large ones. I wish here to record a change of opinion.

The Salmon River drains the southwest part of the Tug Hill plateau in northern New York, where the average annual snowfall is 171 inches and where the spring runoff is both high and flashy. In the summer of 1939 the men from CCC Camp S-113, Camden, built a straight-log dam across the Salmon at Osceola. The main log was 52 feet long, permitting a 5-foot tie into each bank. Spillway width was 24 feet (60 per cent opening) and its height 11 inches above the original bed. The plunge pool, which extends the full length of the spillway, is from 3 to 4 feet deep. The only change from standard practice was the use of 2-inch plank for the facing. This dam has withstood two spring floods and is in perfect condition.

I am now of the opinion that the straight-log dam can successfully be used wherever a log can be found that will span the stream. Timbers longer than 50 feet are hard to get and hard to handle. The Salmon River dam may well represent the practical, if not the theoretical, size limit in the Northeast. —DAVID B. COOK, Albany, New York.

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